THE

2030

ENGINEERING MAGAZINE

AN INDUSTRIAL REVIEW

VOLUME XXIX

April to September, 1905

NEW YORK

THE ENGINEERING MAGAZINE

1905

COPYRIGHT, 1905
BY JOHN R. DUNLAP

EDITORIAL ANNOUNCEMENT.

Mr. Wallace's Papers

THE country is fast reaching a clear recognition of the fact that the Panama Canal is a great problem—great in its promise and opportunities, but great also in its requirements and responsibilities. It is too great to be solved by anything but the best of engineering genius and administrative policy, and it is of course far too great to be even outlined in a single paper. For this reason the following article bears the character of an introduction, and indicates the lines which Mr. Wallace will trace out in succeeding numbers.

No man is better equipped than he to discuss the work from the viewpoint of practical construction. His residence on the Isthmus, in close contact with the details of organization, both in the field and in Washington, have placed him in an attitude towards the undertaking different from that of any other engineer connected with it since the French *régime*. He has had to meet "all the conditions there are" in attempting to place the Canal on the footing of a successful engineering construction. The knowledge of these conditions is essential to a correct understanding of what the country has undertaken to do, and what it must do; but the knowledge has never been presented heretofore. The ENGINEERING MAGAZINE, in this and the immediately following numbers, will place at the disposal of the profession the substance of Mr. Wallace's year of study of the Panama Canal question.

The first section, here presented, as already stated, is wholly introductory. Running rapidly over the preceding history of the project, the author comes down to the appearance of the United States on the Isthmus, under the auspices of the first Commission. The dream of the ages has become the problem of today. How shall we approach it? Surely, without bias or prejudice of any sort—as open-minded and impartial as the traditional "Man from Mars." To such an impersonal

EDITORIAL ANNOUNCEMENT

Continued— *Mr. Wallace's Papers*

judge, the knowledge necessary to decide the case would include, in Mr. Wallace's view, the purpose of the United States in promoting trans-isthmian traffic; the evidence as to the best mode—whether railway, ship-railway, or ship-canal; if the last-named, what route presents the greatest net advantage; finally—purpose, medium, and location being decided—what are the arguments which establish the desirability of settling upon certain engineering details? How shall the field work be organized? And (possibly most important now of all) by what method, direct or indirect, shall our Government carry on the construction? This, Mr. Wallace indicates, is the conception under which he has studied the question, and the spirit animating him is very clearly indicated in the following extract from the paper here presented:

> "The writer desires, through the pages of this magazine, to give the engineering profession, and the country at large, such information as he thinks will, in some measure, be useful in assisting those interested to arrive at a more accurate understanding of the subject.
>
> "It will be his endeavor to consider the subject from the standpoint of a disinterested and unprejudiced investigator, without fear or favor of those who may be selfishly interested politically, financially, or otherwise, eliminating all motives of malice or self-interest. Although it is not to be expected that his views will meet the approval of all, he at least desires that his loyalty to his country and the sincerity of his motives will be appreciated."

The second paper, next month, will take up concretely the work done during the past year, including the organization up to the time Mr. Wallace left the Isthmus, and show clearly what has been actually accomplished, under the attendant conditions. Then will follow a brief description of the various plans proposed, with comment pro and con, and the conclusion will deal with the administrative and executive features of the work, with Governmental methods and their effects as displayed in the results accomplished on the Isthmus, ending with Mr. Wallace's judgment of the situation as he has found it through practical experience.

THE ENGINEERING MAGAZINE

THE WORLD IS ITS FIELD

VOL. XXXIX. APRIL, 1905. No. 1.

SOME ECONOMIC ASPECTS OF ELECTRIC-POWER DISTRIBUTION.

By Dr. Louis Bell.

While Dr. Bell, in the conclusion of his article, rapidly summarizes the accepted standards of electrical and mechanical practice in power transmission and distribution, his discussion is addressed primarily to a much broader aspect of the subject. This is the influence which electric-power distribution is already exercising and will continue increasingly to exercise in re-distributing industry and population. It promises to be a most powerful factor in opposition to the centralizing tendency of steam or water, as direct motive powers for manufacturing establishments, and so to annul many of the worst evils of the factory system and the social conditions accompanying it. The vast and beneficent effect which this may have on material civilization is traced by Dr. Bell, ably and with real inspiration.—THE EDITORS.

MUCH of the complicated mechanism which we are pleased to call modern civilization has for its purpose the survival of the unfittest and the subversion of natural laws. Instead of punishing criminals, we spin fine-drawn theories about them and turn them loose to be a drag upon the progress of decent society. Instead of segregating degenerates in suitable asylums, we form societies for the study of their literary and artistic works and pay two dollars per seat to hear their mephitic plays. We treat economic laws with even more contempt than civil and criminal laws. Professors of the Dismal Science sometimes speak of the law of supply and demand as bearing at least some remote relation to actual human needs, while in reality the basis of many movements in modern industry is the substitution of an artificial law for the natural one. If vested interests have acquired an unprofitable railroad, which upon a sound commercial basis should not have been built prior to 1950, there is at once a cry

for such a "readjustment" of rates as shall charge up the loss to communities along lines which were more wisely planned. Fortunately, civilization brings good along with the evil; and while there is terrible loss of energy in the artificial methods employed, there is still progress, not so much perhaps as the world flatters itself in thinking, but progress nevertheless.

In the last resort, the substance of civilization is human development—all the rest is accidence. The Greeks had no knowledge of steamships, railroads, electric lights, telegraphs, or automobiles—they would have proffered hemlock to the man who had tried to start a telephone exchange; and yet no people ever reached a higher human plane of thought and action. Likewise our little Japanese friends, cheerfully hailed as barbarians barely fifty years ago, had in reality risen to a mental and spiritual height that enabled them in thirty years to grasp the material advances of well-nigh thirty centuries.

The lesson to be learned, then, is to value the achievements of modern science and industry not upon their proceeds in dollars and cents next week or next year, but by their effect upon the growth of humankind and the evolution of a sounder society. In discussing, then, the effects of a particular branch of technical progress, it should be considered in this broader aspect and not merely from the so-called "economic" standpoint which is concerned exclusively with the balance sheet. To come down to the concrete, in the larger view of things it is of little consequence that John Doe should contract for electric power at an annual saving of $10,000, if (as in nine cases out of ten) he will merely put the money into his pocket; the real importance of the gain is measured by the number of people who are benefited by it. If, on the other hand, the contract enables John Doe to put out his goods at a lower price, or to reduce the hours of labor, or to do anything else to the advantage of his fellow man as well as himself, that contract is of direct value to the community. On the contrary, if a similar contract enables Richard Roe to start an industry where none was before, to open a new bit of territory to human activity, the community is at once directly the gainer and electric power is no longer an instrument of private gain, but of general welfare.

Of course, one may say that all private gain goes ultimately to the increase of industry; but unhappily the self-constituted redistributor of wealth is not always a philanthropist in the proper sense of the term, and vague and indirect methods are usually inefficient ones. The special topic of interest here is the direct usefulness of electric power in the generalization of human activity, rather than its possible indi-

rect value in enabling John Doe's heirs to assist in developing the French automobile industry.

The distribution of manufactures in our own or any other country would be a most curious and interesting subject of study. The first thing to stand out conspicuously in the investigation would be the gradual tendency toward concentration in the larger cities, and the gradual recession of manufactures outside them. Certain sections of the country are full of decaying communities, once active, but from which the chief industries have been withdrawn. If investigation disclosed the fact that certain centers of manufacture had become such through the possession of pre-eminent natural advantages, such a condition would be easily explained; but in fact, natural advantages have comparatively little to do with the matter. It is common enough to find large manufacturing plants of a particular kind concentrated in a place that is only moderately good as a working point. Some one shrewdly-managed factory has made a success there, and has gathered others about it, until by sheer force of output and by combination of interests they have frozen out the scattered factories with small capital. Taking into account also the steady tendency of population to move toward the cities for various causes, the outlook for local enterprises seems far from good. In fact, the situation is fraught with the gravest dangers to the community at large. A country consisting mainly of large cities with merely incidental rural population has taken a long step toward final disintegration. Moreover, even if actual disintegration is not imminent, there exists the curious and anomalous condition of a community in which the transportation and distribution of commodities is the predominant element—in which producer and consumer stand at the ends of a long chain of intermediaries. It is bad enough in this respect, even at present, but every step toward further concentration of industry and population makes it worse. No country in which the productive forces are steadily being subordinated to an intricate (and, upon the whole, wasteful) mechanism of distribution can long remain prosperous.

It is the recognition of this general principle that is the basis of the present agitation for regulation of railway rates and of similar movements.

Starting with the condition that wide distribution of industries is desirable in order to render more simple and efficient the mechanism of commerce, there are two prominent factors in the problem at hand. The first is improvement in the organization of transportation so that needless work can be in part eliminated. The second

is such an equalization of the industrial conditions that bear upon manufacture as shall minimize the legitimate need for transportation. For economical manufacturing, one must have moderate costs of raw material, labor, and power. The two former items are strongly affected by transportation conditions, as is also the last-named when its source is fuel.

The importance of electric-power distribution from this standpoint is already great and will become greater. If one takes a map showing the distribution of coal in the United States, it is at once apparent that by far the greater part of the territory either has no fuel at all, or little, and that of poor quality. Wood has been practically eliminated from the question by the rapacious wastefulness of the last quarter-century. Hence as regards the country at large there is a heavy transportation change on power. Within the past ten years we have learned to utilize the water powers of the country (which, by the way, are as a whole in the regions having least fuel) and cheap electric power has already done much to open new fields to manufacture, especially in the South which is the natural field for cotton manufacture. In one particular the present working of hydraulic power is very faulty, and to this defect I wish to direct especial attention. In spite of the great growth of electric-power transmission, its effect on the consumption of fuel has thus far been very small, owing to the fact that the great mass of hydraulic power, which is in small units, has practically not been touched at all.

Of our total water power, probably four-fifths is in falls below 1,000 horse power in capacity, and at the present time money can rarely be found for the development of small enterprises of this kind. Bankers as a rule have not the slightest interest in these small permanent investments. They will lend moderate amounts upon quick assets, but frankly say—and with a showing of truth—that they can handle a bond issue of a million dollars with no more labor than one of a hundred thousand, and with ten times the profit.

To my personal knowledge, there are scores of water powers in New England able to furnish preposterously cheap power for small industries by transmissions of trivial length, but they are cases for private investment and not for "financing." By utilizing such privileges it will often be possible for small industries to obtain power at less than half the cost paid by their larger competitors. The present adverse factors are mainly due to transportation. Putting aside the instances of deliberate discrimination in rates—which are altogether too common—there is a strong general tendency toward punishing the industries

in small places situated on non-competitive lines. At this point the electric railway is beginning to come in as an ameliorating influence, and if its development is allowed to go on unimpeded, much good will be done. Every electric railway network means a readier market for every point touched, and when light freight haulage becomes more general the influence will be very strongly felt, unless the non-urban communities are foolish enough to allow the electric systems to be captured by the steam roads which now hold the field. The small hydraulic powers already referred to are well able to furnish cheap motive power for transportation, if given the chance, and thus to make the regions served more self-supporting and self-reliant.

The effect of cheap electric power in encouraging and conserving small industries has already been well demonstrated, particularly abroad. In several regions on the Continent its introduction has preserved the industrial autonomy of large groups of villages threatened with extinction by the very forces more conspicuously active in the United States. Since the existence of a small industrial center means increased prosperity in all the region about it, the value of such a policy to the community is all the more evident.

Bearing in mind the cost of transportation, the manufactures which can profitably be carried on in small places having cheap power available are especially those in which the value of the finished product is due mainly to the expenditure of power and labor, in particular highly skilled labor. Besides these, there are also some industries in which the raw material can be obtained locally. It is sometimes popularly supposed that skilled labor is not easily obtained outside of considerable cities. It is perfectly true that in certain lines skilful workmen are now mostly to be found in large industrial centers, but on the other hand they are the easiest class to get away from these centers when good employment offers. It is the ordinary "lumper" who is most gregarious and who is most unhappy when withdrawn from the associations of the city. And in fact, in small places where the workmen are stable and responsible members of the community the difficulties of the labor situation are at a minmum.

To come to concrete figures, there are today many unutilized powers ranging from 200 to 500 horse power that can be acquired and developed, including an electric transmission of moderate length, for about $100 per horse power delivered. They are cheap simply because they are on rather small streams easily controlled in places where at present there is small demand for power. A factory wishing power can thus obtain it, as the investment cost shows, at a very

moderate rate and in the majority of instances can get the few hours of hydraulic storage necessary for utilizing enough of the energy for lighting to offset no inconsiderable part of the expenses. There are now not a few small industries clustered about little water powers, but electric transmission has yet to play its part in bringing isolated waterfalls into use where there are existing facilities for transportation. It is almost an untouched field and one of great promise.

As an extension of the same idea one should consider the new phase of power transmission which unites into net works the available powers of a considerable region. This is the basic principle of some very considerable systems and applies with equal force to smaller ones. Given three or four small powers within a few miles of one another, and when united they can not only furnish their aggregate power at one or several points but are generally available for an amount considerably greater than the sum of their nominal powers. It often happens that one of the lot has available storage greater than would be advisable to utilize independently, but which can be used very economically to help out the entire group. I call to mind one case with several plants on the same stream where the storage of the upper one can be conveniently used in all those below, the time of flow between consecutive stations being sufficient to equalize the output very neatly. Moreover, when several plants are united in a network, the need for duplicate lines is diminished since most points of the network are fed from at least two directions.

Carrying out this principle it is quite feasible to group and utilize several powers, individually of modest size, so as to put electric power into many places where it will be profitable to use it; into every conveniently situated village in a county for the upbuilding of local industries. That which is already done profitably over an area of many thousand square miles can certainly be made highly successful over a few hundred square miles. This work with small powers is relatively very easy, for the distances of transmission are generally very moderate so that no problems of extreme high voltage are involved; the developments of the hydraulic side are usually easy, since the volume of water to be controlled is small, and simple methods can be employed throughout. It is now common practice to run several transmission plants in multiple, so that nothing is to be feared on the operative side of the work. The sole difficulty is the financial one, arising from the small amount of securities involved and a certain disinclination to consider country affairs seriously. The work is most emphatically one most profitably to be

undertaken by local interests, interested directly in earning power rather than promotion.

As power propositions are generally financed, the funded debt is expected to cover the whole expenditure, including profits to those who handle the bonds, the entire stock issue being *aqua pura.* Under these conditions the absence of large stock dividends is not evidence of poor business. On the cash actually put in, a well planned power plant, even on a small scale, will generally pay a handsome rate of interest after setting aside a liberal reserve for maintaining the value of the property.

In caring for small industries and developing local resources, Continental Europe is far ahead of the United States. In France, Germany, and Switzerland, there has been a keen interest in preserving manufactures against the inroads of centralization, and a good many electric plants, both large and small, have had this aim in view. The task is rendered easier by close Governmental control of transportation. In America, on the contrary, the tendency toward industrial centralization is at present very strong, and almost wholly uncontrolled. Each census shows worse conditions in this respect, without compensating advantages. It is small glory to have rapidly growing cities fed by depletion of the rest of the country, when at the same time economic waste is increased.

The practical problem to be solved is to make the non-urban regions industrially more useful; and as already pointed out, electric-power distribution and communication gives at least one efficient decentralizing agency. In a concrete case things would work out somewhat as follows:—

A factory starts up in a small town with transportation facilities now reasonably good. With some aid from local interests, it takes up and improves a neglected water power a few miles away; and, not needing the whole output, sells what it can for power and light, thus obtaining its own power at a very low figure. It brings in workmen, not as waifs, but as permanent residents, casting their lot definitely with the community. Presently, ability to get cheap motive power starts someone else at working a small shop; a few more workmen come, business in general begins to feel the effects of the movement, and before long another water-power is pressed into service and tied in with the first, picking up another village on the way with a casual shop and a little lighting.

By this time there has been influx of workmen enough to encourage starting an extra store or two; and then another factory,

scenting cheap power, comes along and settles down to business. The united water-powers are pretty well loaded, but then the community is now thoroughly interested; some enterprising individuals pick up a third power ten or a dozen miles off, develop it, and add it to the others, catching an incidental village or two on the way. Each added community adds a few shops, and before long it is time for a little electric road connecting all with the railway. A little telephone exchange starts up and gets connected with the long-distance lines, and within a few years the whole region, covered by the electric net work, takes on an air of new prosperity; the population increases, the farms find a home market, and instead of a decaying backwoods community with one lonely general store, a tumble-down church, and a cider-mill, we have a lively little group of towns, each hustling to get ahead of the others, in close touch with the nearer cities, and a part of the industrial world. There are today little towns manufacturing specialties that are known everywhere, and with decent utilization of natural resources to give cheap power, their number might be increased tenfold. And the modest prosperity thus acquired is stable to a far greater degree than that which depends upon huge urban aggregations of manufacture. The little factory does not shut down because a prominent broker has been speculating too freely, or because a foreman has employed a non-union scrub-woman.

Technically, the task of organizing a power network for such uses is very straightforward indeed. It simply means following out intelligently principles already familiar. The transmission and distribution of the power is done generally by ordinary polyphase methods, which may perhaps be supplemented more or less by single-phase circuits for small powers. Abroad, some few plants have tried continuous-current distribution with series motors, but the high motor voltages are objectionable on the score of safety. The most interesting feature of engineering small plants lies in the tactful use of water storage. For example, take a power giving 300 horse power off the shaft of the wheel. The normal generator in such a case would be of about 200-kilowatts capacity. This could easily be used up in power and could be put to use in lighting only after the period when lap-load occurs. But flash boards and two or three acres of storage at a working head of, say, 25 feet would put another hundred kilowatts into service for the couple of hours necessary to carry the load over the peak, so that the plant could earn moderately at least for 24 hours per day at no great added expense. A few

additional acres will sometimes work wonders. I call to mind, right in New England, several instances in which, at a low figure, enough storage is attainable to carry a plant over the entire dry summer season. The trouble heretofore in the electrical-power business has been that men were hunting for big streams with several-thousand horse power available for long transmissions to the larger cities, and altogether overlooked scores of available small powers, relatively much cheaper to develop and with far nearer markets.

The number of big transmissions is necessarily limited—there is but one Niagara, but one great cataract on the Zambesi. Though the former may be loaded to its utmost, and the latter may turn every wheel from the Equator to the Cape, the bulk of the world's power will still remain in small units. The world's coal supply, while in the aggregate probably much larger than is generally supposed, is being drawn upon at a rate that implies, merely from increased difficulties of mining and lengthened transportation, a steady increase in price; but the rains will still fall and the rivers flow when our coal has to come from Thibet or Matebele Land.

Long before that time, the industrial salvation of a country will be the utilization of its smaller powers. And every beginning made now will help to put off the day when the earth will have to call on the skies for heat as well as motive power, or shift its activities nearer the Tropics. Meanwhile the prosperity of our own and other countries depends upon opening wider areas to human activity, instead of still further confining it to great centers of population.

MODERN MACHINERY AND THE PANAMA CANAL.

By A. W. Robinson.

The first part of Mr. Robinson's very valuable study of the Panama Canal problem occupies the following pages. The concluding portion—a summary of the "Available Types of Dredging Plant"—will appear next month.—THE EDITORS.

IT is confidently expected that the work of excavating the Panama Canal can now be performed with less expenditure of time and money than would have been possible a few years ago. Let us examine the question to see what similar works did actually cost, and also see what tools are now available for the work, and how much better—if any—they are than their predecessors.

For previous examples, we will consider the Suez, Manchester, North Sea, Chicago Drainage, and St. Lawrence canals, and also look a little at other large works involving excavation, as railroad building and iron-ore mining. All these works are of course widely different from one another, and still more different from the Panama Canal as to conditions, and therefore direct conclusions that would apply to the great canal now contemplated cannot be drawn from them without ample allowance for such differences.

I will not attempt in this article to settle off-hand the great problems of the design of the canal that are now being considered. These are questions that involve the most complete exploration and study, and after all the data are got together, the most careful analysis of a trained judicial mind coupled with the highest engineering skill. The general public, and it is to be regretted some engineers also, are too apt to crystallize their first impressions into fixed opinions on a too slender basis of fact. Thus at one time the general public had a firm belief in the superiority of the Nicaragua route, and engineers are already arguing the relative merits of a sea-level canal vs. locks before the full data have been secured. Leaving room for honest differences of opinion, it is quite possible, after all the requisite investigations are made, to review the evidence and make an engineering analysis of conditions and requirements, and to arrive at a logical conclusion as to a type and design of canal that will be best. Modern conditions and modern requirements have advanced since the previous schemes were drawn up, and a canal is now demanded that will reasonably fulfil the requirements of the near future, that will be capable of extension and expansion as those requirements grow, and that can be opened for business within a reasonable time and cost.

Among the considerations in favor of the lock system are: (1) shorter time of construction; (2) less cost; (3) better solution of the hydraulic problems, particularly the control of floods. With modern methods of construction and operation, locks are perfectly reliable, and are quickly operated by power, so that the delay to vessels is not great. On the other hand, a canal with locks can never be enlarged. Lock foundations once in, the die is cast. Should traffic require larger accommodation a new canal must be built—or new locks, for which it might be difficult to find a site and increased water supply. If it can be shown that the more quickly built lock canal can be subsequently enlarged into a sea-level canal at a fair proportionate cost without interfering with its operation, this point would be met. No such evidence has yet been adduced.

A lock canal cannot be enlarged in the ordinary sense of the word. The so-called Erie Canal "enlargement" is practically a new canal. The Welland and St. Lawrence canals have been "enlarged" recently from 8- to 14-foot depth. How? By building an entirely new canal in a new location, which is in places several miles distant from the old. In this respect railroad transportation is essentially different from canal transportation. A railroad is capable of improvement and expansion to meet the growing needs of traffic. Built at first in a cheap and temporary way, it can afterwards by improving the roadbed, rolling-stock, and grades, increase its capacity six times or more. A canal, on the other hand, is bound by its lock dimensions and cannot be enlarged by any method short of complete rebuilding. This consideration is an important factor in the competition of canals and railroads for internal transportation, and helps to explain the fact that small canals have relatively decreased in importance and usefulness, and the railroads have increased.

Locks of 100 by 1000 feet have been recommended, but as the operation of such locks would be wasteful for the smaller and more numerous vessels, it is probable that two or more sets of locks of different sizes would be needed. Who can forecast the ships of the future, when their size has doubled in little more than ten years?

With a sea-level canal, the volume of excavation is greatly increased. This increase, however, is almost wholly in the high ground, where healthful conditions prevail, and where the work of excavation, though enormous, can be more adequately accomplished by the modern machinery later to be described than by those of De Lesseps' day. As far as excavation is concerned, it is simply the removal of a known volume of material at a known unit cost as now determined by the experimental plant of the present com-

mission. The hydraulic problems of a sea-level canal are serious, and upon their satisfactory solution the outcome will mainly depend.

Coming now to actual examples, many comparative statements of existing canals have been published, but the following table has been compiled from original sources, and gives the leading facts in condensed form:—

TABLE I.—DATA OF FIVE OF THE LEADING CANALS OF THE WORLD.

	Suez.	North Sea.	Manchester.	Chicago.	St. Lawrence.
Total length, miles	99	61	35	28	73
Depth, feet	26	29½	26	22	14
Width at bottom, feet	72	72	120	110	100
Number of locks.	..	2	5	...	48
Total rise of locks	..	tidal.	71½	...	551
Length of locks.	..	..	600	...	270
Width of locks..	..	..	65	...	45
Total volume of excavation, cubic yards	99,400,000	104,630,000	53,500,000	40,000,000	.....
Total cost of canal	$93,000,000	$39,000,000	$65,400,000	$28,411,920	$85,342,000
Cost ÷ number cubic yards	93 cents.	37 cents.	$1.22	71 cents.	.....
Year of beginning	1859	1887	1887	1892	.....
Year of completion	1869	1895	1893	1900	.....
Years in building	10	8	6	8	.....
Maximum number of men employed	25,000	10,000	17,000	8,000	.....

Suez Canal.—In the Suez Canal the physical conditions presented no special difficulty. The material was mainly sand, with some rock in thin strata near Chalouf, and the greatest elevation to be cut through did not exceed 60 feet, and that only for a short distance. The tides are inconsiderable, necessitating no costly controlling works. Labor was abundant, and so cheap that it competed successfully with mechanical methods for much of the work. In the early stages of the work hand labor with wheelbarrows and buckets was largely used, and men even scooped the mud with their hands. The whole of the cuts through the high ground were taken out in this crude way, the rate of wages being 15 cents to 20 cents per day, without board. Concerning this part of the work, Prof. J. E. Nourse states:—*

> "To effect a channel through the 27 miles from Port Said to Kantara, was a work of greater difficulty than that executed at the port. The sulphuric exhalations of the mud, when stirred under the burning sun

* Maritime Canal of Suez. 1884.

of Egypt, were almost insupportable; yet not much more sickness was reported to have occurred than in other localities. The lake fishermen threw up the liquid mud with their hands to form a dike, which, under the powerful sun, quickly dried. When something like an opening had been made and water began to flow in, rafts were constructed on which thousands of these men slept under tents made of mats. An excavation of 40,000 metres was effected.

"When the men had scooped out with their hands a passage of sufficient dimensions, dredging machines were introduced and the trench was widened until it reached the dimensions of 330 feet wide and 20 feet deep. The banks on both sides were solid and firm. On these the dredgers with long shoots were subsequently used, which dispensed with the expensive mode of disposing of the débris into hopper barges and then conveying them to sea to be emptied. The first little dredger (carried in sections across the mud) was followed by twenty more, which excavated two ditches 20 or 25 metres in width, leaving the intermediate space to be excavated by the dredgers with long shoots."

All the dredges were of the endless-chain type, and at first the material was deposited into barges and dumped in the lakes or in the sea. Soon great difficulty was encountered in getting rid of the stuff, and dredges with a long shoot or "couloir" were devised. In these dredges the material was raised to a height of 40 to 44 feet and dumped into a hopper, whence the spoil was carried ashore in a couloir some 220 feet long. This couloir consisted of a trough or spout carried by a skeleton frame or cantilever of wrought iron, the base of which rested on a separate float alongside the dredge. The couloir had a slope shorewards of about 1 in 10, and the discharge was assisted by a stream of water, and by a chain with scrapers attached which was caused to travel down the bottom of the couloir. The buckets of the largest size had a capacity of 14 cubic feet and passed at the rate of 20 per minute. The average output of 22 of these dredges was 36,000 cubic metres (46,800 cubic yards) per month each.

The greatest difficulty was to dispose of the material on the bank satisfactorily, and it is evident that, whatever the length of the couloir, the deposit of mud, sand, and water, must sooner or later reach a point at which some of the material will run back again.

The Suez Canal was undoubtedly a great achievement in its day with the appliances then available, but there is but little in it that furnishes any useful data for meeting the problems of the Panama Canal of today. The conditions are entirely different and vastly more difficult, even with our superior appliances. De Lesseps, confident of victory after the success of his first achievement, boldly attacked the Panama problem—and we all know how he failed, notwithstanding his splendid optimism and indomitable will. These

qualities applied to Panama difficulties are precisely the ones that would lead to disaster.

The large dredges at Suez were a great improvement over hand labor and were able to accomplish 50,000 cubic yards per month. A large and powerful hydraulic dredge of today has a capacity ten times as great, or 500,000 cubic yards per month. One large dredge designed by me has, under exceptionally favorable conditions, made an output of 750,000 cubic yards in one month.*

North Sea Canal.—In this canal of recent date, one would expect to find good organization, modern plant, and a generally well carried out scheme. The Germans are scientific and systematic, and in their dredging machinery they are well advanced. In excavators for dry work the standard machine used is the endless-chain type which requires a level track of five rails and a crew of thirty-six men. These machines, of which the Lubeck Company has built such a great number, were largely used for the dry excavation. Here also we first find hydraulic dredges, used with long discharge-pipes, but they were of comparatively small size. Most of the subaqueous dredging was done with endless-chain machines of the ordinary type. The conditions being favorable, climate good, wages low, and the work done in the midst of a country of abundant resources, we find the unit cost low. The canal was opened on the date originally set for it, and no additional grants of money were asked for beyond the original estimate. The estimated cost was as follows:—

TABLE II.—COST OF THE NORTH SEA CANAL.

Ground	$2,500,000
Excavating and dredging	17,500,000
Embankments	2,000,000
Locks and quays	9,000,000
Bridges and ferries	1,750,000
Fortifications	375,000
Canal boats, magazines and shops	375,000
Hydraulic and electric installation	500,000
General expenses and compensations	1,250,000
Contingencies	3,750,000
Total	$39,000,000

The above cost is that given in Table I, and although it is probable that some items exceeded the estimate, I have been unable to find to what extent, or to obtain official figures of the actual cost.

Manchester Ship Canal.—This work was commenced under a contract with T. A. Walker for £5,750,000 ($27,945,000), but in

* See Engineering News, July 28, 1904.

November, 1890, the Canal Company abrogated the contract and undertook to complete the work themselves. Difficulties had arisen over extras and unforeseen conditions, which increased as time went on. The total capital expenditure up to the end of 1890 was £9,047,000 ($43,968,420). The total cost of plant to this date was £943,000 ($4,582,980).

The total cost of the work is stated as follows:—

TABLE III.—COST OF THE MANCHESTER SHIP CANAL.

Construction work, including plant	$43,068,153
Bridgewater canal	8,661,355
Right of way	5,644,146
Interest	5,047,110
Other expenses	3,044,508
Total	$65,465,272

The total excavation was 53,000,000 cubic yards, of which about 10,000,000 yards was sandstone rock. The plant included 173 locomotives, 97 excavators, and 8 dredges. The majority of the excavators were the Ruston & Proctor "steam navvy," a machine similar in principle to the American type of steam shovel, but differing from it in several particulars, the more important being that the English machine has a short car mounted on four rigid wheels, and a single pair of engines performing all motions by means of clutches. The American machine, on the other hand, has a long car mounted on two flexible trucks, and has three separate engines for the motions of hoisting, swinging, and dipper-feeding. It will readily be seen that the two trucks and eight wheels of the American machine would be more flexible on an uneven temporary track, and on account of less load per wheel would be easier to hold up on soft ground, and would be better adapted for traversing sharp curves. By means of the separate engines, all motions can be performed simultaneously, resulting in great increase of speed. The Ruston & Proctor machines, although slow, were very efficient in results and cost of work done, as the cost of labor was very low. A 2¼-yard machine cost at that date £1,200, and has done as much as 2,000 cubic yards per day of 12 hours in sand, but 600 to 700 cubic yards may be taken as a fair average. The working expenses were low, being stated at 30 shillings ($7.50) per day.

There were also four French excavators, by Boulet of Paris, and three German, by the Lubeck Company. These were chain-bucket machines, requiring a well-laid track of five rails on which to operate, and a total crew of thirty-six men. These machines make an average output of 1,500 cubic yards per day in earth. A good Amer-

ican type of shovel of equal capacity can deal with harder material, can work equally well on a temporary track of two rails thrown on the ground, and requires only two skilled men and six laborers.

The construction work on this canal, including locks, cost $43,068,000. As the excavation was 53,000,000 cubic yards, this is equal to 81 cents per cubic yard. This appears a high cost when it is considered that the conditions of labor, climate, and material were favorable. It is partially accounted for by the fact that about one-fifth of the volume was sandstone rock, and also that the nature of the country necessitated much expense in disposing of the soil. It could not be dumped directly on the bank opposite the cutting, as was done at the Chicago Canal. The cars, locomotives, and excavators were also all light and of small capacity compared with American practice.

Chicago Drainage Canal.—This work is not (for the present at least) a navigation canal, and it is introduced here only as an example of excavation. The unit cost does not compare unfavorably with similar works, especially where it is considered that a large percentage was rock and glacial drift. The unit cost is about double that of the German canal, which would be alone accounted for by the fact that the excavation of the harder material would naturally cost twice as much as the soft material of the North Sea Canal. In addition to this, American labor costs about double that of Germany, which would indicate that the American appliances were more efficient. The spoil from the canal was deposited for the most part on the banks directly opposite the cut, forming two high embankments. In this canal, as at Suez, the excavation is the principal item of cost, the subsidiary works being less in proportion than at Manchester or the North Sea.

The work was carried out by contract under the direction and control of a board of trustees. Numerous small contracts were let, and each contractor followed his own notions as to how the work should be done, no two being alike. Much ingenuity was displayed and an interesting object lesson furnished as to methods and results. It is safe to say that, were such a work to be repeated, the experience gained would enable much better results to be secured. So great and rapid has been the advance in the art of dredge and shovel building, that probably not one of the excavating machines used on this canal would be duplicated from choice today.

St. Lawrence Canals.—The data given for these canals in Table I includes the St. Lawrence Canals, the Welland Canal, and the Sault Ste. Marie Canal, the cost being the total capital expenditure to June 30, 1903. These canals, although in separate lengths, are part

of one great system, and have in several instances been enlarged and rebuilt. The total volume of excavation for the whole system is not given, but in Table IV are given data of the Soulanges Canal, one of the more recently completed sections, and which represents a modern and well-equipped work of its size.

TABLE IV.—DATA OF SOULANGES CANAL.

Total length, miles	14
Number of locks	4
Rise of locks, feet	82½
Estimated cost	$4,750,000
Actual total cost	$5,792,066
Total volume of excavation	7,608,319
Cost:—number cubic yards	76 cents.
Year of beginning	1893
Year of completion	1899

In considering the above unit cost it must be remembered that the proportion of subsidiary works, as locks and spillways, was large, and is all included. This canal was executed at ordinary American prices of labor, but machinery and tools cost about 25 per cent. more than in the United States and the climate permitted work for only 7½ months in the year.

In Table V are given in detail the quantities and cost of excavation. This work was all done by contract, and therefore includes every expense and contractor's profit.

TABLE V.—QUANTITY AND COST OF EXCAVATION AND MASONRY IN SOULANGES CANAL.

	Quantity, Cu. Yds.	Cost.	Cost per Cu. Yd.
Earth excavation	7,264,457	$1,818,308	$ .25
Rock excavation	343,862	334,926	$ .97
Total excavation	7,608,319	$2,153,234	
Masonry	52,767	626,718	$11.88
Concrete	161,048	491,524	$ 3.05

The River St. Lawrence ship channel is a good example of economical dredging work on a large scale. The total amount dredged to June 30, 1903, is 36,654,600 cubic yards at a total cost of $4,910,-155 or an average of 13.4 cents per cubic yard.

Iron Mining and Stripping.—A class of excavation work of sufficient magnitude to be noted here is the opening up of the great iron mines of the Lake Superior district. This work is done exclusively by powerful steam shovels of American type. Many of the great mines are open pits, and the ore is uncovered by stripping off a thickness of material sometimes as great as 100 feet over a large area. On the Biwabik Mine alone, 4,000,000 cubic yards of overburden containing gravel, hardpan, and boulders were stripped off

to permit of the further excavation of 5,500,000 tons of ore, all of which was done by steam shovel. On this class of work very heavy and powerful shovels are used. A common size is 3½-cubic-yard dipper upon which the engine pull exerted is 60,000 pounds. Such a shovel has been known to load as much as 6,000 tons of ore in 10 hours under favorable conditions. A good average, however, is 3,000 tons, including the delays incidental to such work. This is equal to, say, 2,000 cubic yards of ordinary earth or clay.

As to cost of this work*:—contracts for removing surface at these mines in the earlier days averaged 40 cents per yard. Now, owing to improved methods, standard-gauge equipment, and greater operations, they are not in excess of 30 cents. Actual costs, including repairs and depreciation, but not including profit, for stripping in fairly favorable locations will run from 15 cents to 18 cents per cubic yard, and in some difficult work have not been in excees of 18.5 to 20 cents. This work is done with cars of about 80,000-pound capacity, hauled by powerful locomotives, and covers all expense of maintenance, shifting track, hauling up-grade out of the pit, dumping, etc. The cost of moving the ore is less than that of the overburden. It is heavier and more compact and homogeneous. The digging of the ore and loading it into cars is one of the least items of cost in the total process, and under ordinary conditions a cent, or a cent and a half, per ton will cover it.

In the thirteen years of development on the Mesabi Iron Range more than 16,000,000 cubic yards of overburden have been taken from its mines, at an approximate expense of between five and six million dollars, and the mines have produced 78,000,000 gross tons.

Reviewing the examples cited, it appears that the North Sea Canal was the most economically executed work of its size, and that for dry excavation under American conditions the Lake Superior iron ranges offer the best example of large operations economically executed in difficult material. The experience and results of other works as set forth in this paper are of great comparative interest, but cannot be taken as a basis of cost at Panama, because the work will be done with different tools and under different conditions. The advance which has been made in mechanical appliances for dredging and excavating since those works were executed is very great, and it is certain that modern machines of large capacity specially designed to suit Panama conditions will go far toward offsetting the disadvantages of those conditions.

(Mr. Robinson's second article, "Available Types of Modern Dredging Plant," will appear next month.)

* Engineering & Mining Journal, February 9th, 1905.

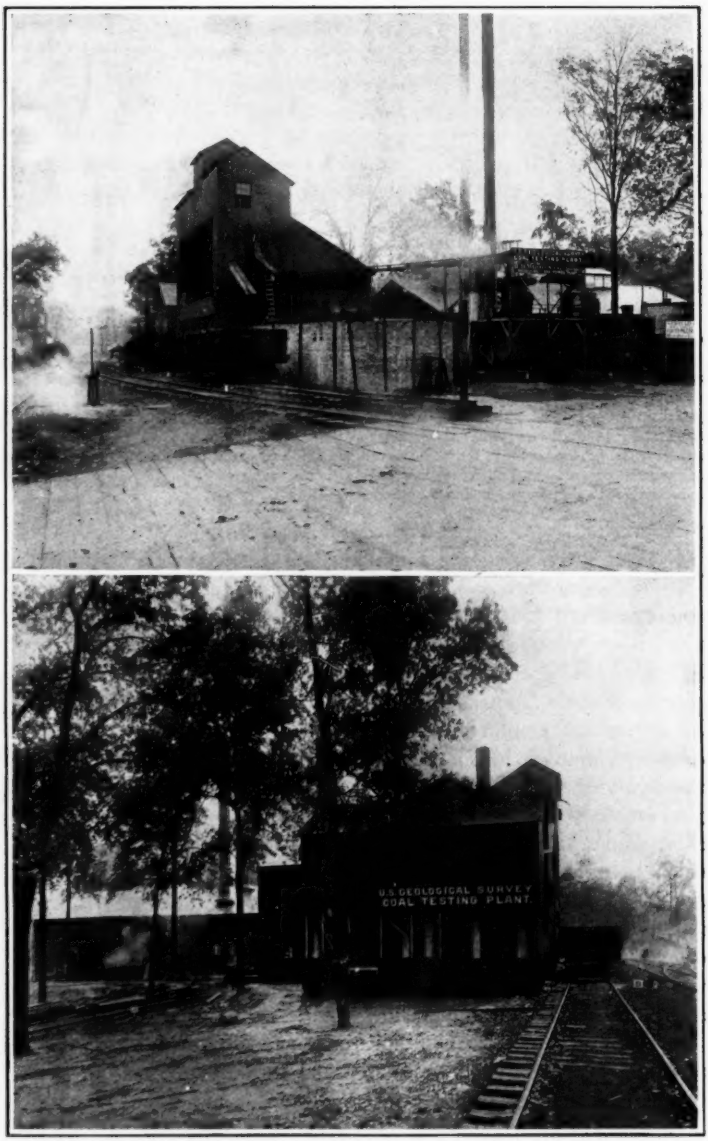
TESTING COALS AND LIGNITES AT THE ST. LOUIS WORLD'S FAIR.

By Edward W. Parker.

The coal-testing work carried out at the St. Louis Exposition—and, it is most earnestly to be hoped, to be continued by further Goverment provision—is probably the most interesting and valuable study of the kind ever undertaken. It is, in brief, a comprehensive, able, and wholly impartial examination of American fuels on a full working scale. We are glad to present herewith the first part of a concise account of the work and the results, prepared by the authority in actual charge of the station. This deals with the general equipment and organization of the plant, the manner of making the tests, and the chemical and steam-raising trials. A second article, next month, will follow with the gas-producing, coking, and briquetting tests and their results, and with the comparative steam-raising and gas-producing values determined in the various fuels.—THE EDITORS.

IN presenting this summary of the results obtained at the Coal-Testing Plant of the United States Geological Survey at the Louisiana Purchase Exposition, a few notes in the way of introduction may not be out of place. In the first place, it should be stated that the suggestion originated with Prof. Joseph A. Holmes, the chief of the Department of Mines and Metallurgy, who believed that the construction and operation of such a plant during the Exposition would be an interesting feature of the Mining Department, and would in addition demonstrate that such lines of investigation carried on by the general Government would be of great value not only to mine operators, but to consumers as well. There is no substance extracted from beneath the earth's surface which appeals so directly to the people, whatever their condition, as coal. Gold itself is no exception, for many thousands of us do not see a piece of gold, especially as coin (its one real use) from one year's end to another, nor appreciate its place in the world's economy. But coal—black, dirty, unattractive coal—appeals directly to nearly every one, high or low.

When, therefore, Prof. Holmes presented his plans to the director of the Geological Survey and asked for his co-operation in the securing of an appropriation for the work, it was immediately obtained. Comparatively little opposition was encountered in securing favorable action from Congress, the members of the appropriations committees of both House and Senate readily appreciating the im-



TWO VIEWS OF THE COAL-TESTING PLANT. THE UPPER IS TAKEN LOOKING EAST, AND SHOWS THE WASHERY AND STORAGE BUILDINGS, THE COKE OVENS, AND PRODUCER PLANT. THE LOWER VIEW IS LOOKING WEST.

portant possibilities of such a plan, if it could be carried out without too great an expense.

It might be stated here that Prof. Holmes was fortified by promises from quite a number of manufacturers, to supply free of cost to the Government practically all of the equipment necessary for this pioneer work. Relying upon these assurances, Congress voted two appropriations, each of $30,000, the first being carried on the Urgent Deficiency Bill approved February 18, 1904, the second on the General Deficiency Bill approved April 27, 1904. Each appropriation was made for "analyzing and testing, at the Louisiana Purchase Exposition, the coals and lignites of the United States, to determine the most economical method for their utilization, under the supervision of the director of the U. S. Geological Survey,—*Provided*, that all testing machinery and all coals and lignites to be tested should be furnished to the Government free of charge."

It may be supposed that under this provision, the construction of an ideal testing laboratory was hardly possible, particularly when the short space of time in which to do the work is considered. But the committee in whose hands the work was placed believe that even with full authority for the purchase of equipment, it would not have been possible, in the time allowed, to have assembled and installed a more complete and satisfactory plant than that which was secured through the hearty, and one might say patriotic, co-operation of manufacturers and of the transportation interests. The railroad companies contributed sometimes by billing free, and always by seeing that the utmost dispatch was had in delivery of cars containing machinery and other supplies for the coal-testing plant. The companies contributing equipment, which was entered as exhibits, were as follows:—

Heine Safety Boiler Co, two water-tube boilers each 210 horse-power.
Allis-Chalmers Co., one Corliss engine 250-horse-power.

Westinghouse Machine Co., one vertical three-cylinder gas engine 235-brake-horse-power.

Bullock Electric Manufacturing Co., electric generator, belt-connected to Corliss engine.

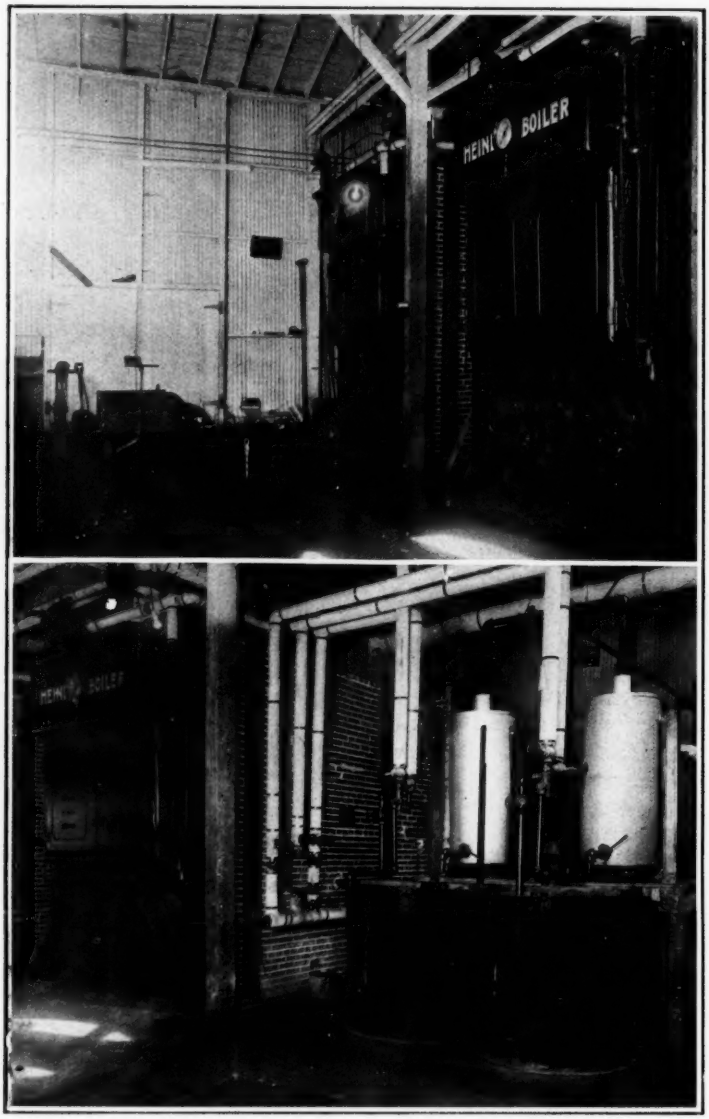
Westinghouse Electric & Manufacturing Co., electric generator, belt-connected to gas engine. Also full complement of motors and appliances used in operating the plant.

R. D. Wood & Co., Philadelphia, Pa., one No. 7 Taylor gas producer. with economizer, scrubber, tar extractor, purifier, and holding tank.

Frost Engine Co., Galesburg, Ills., one fire-tube boiler, 100-horse-power, and one slide-valve engine, 50-horse-power.

C. O. Bartlett & Snow Co., Cleveland, Ohio, rotating dryer.

Wm. Johnson & Sons, Leeds, Eng., briquetting machine.



THE BOILER ROOM. IN THE UPPER PICTURE ARE SEEN THE COAL-WEIGHING CAR AND SCALES, AT THE LEFT; IN THE LOWER ONE ARE SEEN THE WATER-WEIGHING TANKS.

National Compressed Fuel Co., Chicago, Ills., briquetting machine.

Laclede Firebrick Manufacturing Co., St. Louis, Mo., firebrick for coke ovens.

Williams Patent Crusher and Pulverizer Co., St. Louis, Mo., one Williams Crusher.

Robins Conveying Belt Co., New York, a complete outfit of belt-conveying apparatus.

Fairbanks, Morse & Co., scales.

Hohmann & Maurer Manufacturing Co., Rochester, N. Y., thermometers and pressure gauges.

Appliance Manufacturing Co., Chicago, Ills., draft gauges.

Stilwell-Bierce, Smith-Vaile Co., Cincinnati, Ohio, feed-water heater and pumps.

Charles Engelhard, New York, Le Chatelier pyrometers.

Ashcroft Manufacturing Co., New York, and Crosby Steam Gage and Valve Co., Chicago, Ills., engine indicators and attachments.

Steel Mill Packing Co., Detroit, Mich., metallic piston packing.

American Arithmometer Co., St. Louis, Mo., Burroughs adding machine.

American Steel and Wire Co., Chicago, Ills., insulated electric wire.

Waters-Pierce Oil Co., St. Louis, machine and engine oil for lubricating the machinery, and heavy oil and medium oil for binding material in the manufacture of briquettes from bituminous coals and lignites.

Famous Filter Co., St. Louis, Mo., oil filter.

Pittsburg Meter Co., Pittsburg, Pa., gas meters.

Austin Manufacturing Co., Chicago, Ills., dumping car and bucket conveyors.

Henion & Hubbell, Chicago, Ills., centrifugal pump.

Barrett Manufacturing Co., New York, and the Chatfield Manufacturing Co., Cincinnati, coal-tar pitch.

F. W. Braun Co., Los Angeles, Cal., power crusher and automatic sampler for preparing samples for the chemical laboratory.

Buck Stove and Range Co., and Bridge & Beach Manufacturing Co., both of St. Louis, cooking range, for the purpose of testing briquettes for domestic use.

Keuffel & Esser Co., New York, calculating machine.

The committee appointed by the director of the Geological Survey to carry on the work consisted of Prof. J. A. Holmes, M. R. Campbell, and the writer. In the organization of the work it was determined that the investigations must be limited to standardized methods and equipment—that both the letter and the spirit of the law were against the testing of apparatus, or of methods, but were definitely confined to the testing of coals and lignites. So, while recognizing that certain collateral lines of investigation might be well worth trying, and that the results obtained might prove of great value in the settlement of a number of interesting problems, the committee felt compelled to restrict itself to the purposes set forth in the Acts of Congress making the appropriations. For this reason,

in the steaming tests, for instance, the furnaces were hand-fired and only natural draft was used. It would have been interesting to have tested many if not all the coals with various automatic or other smoke-preventing devices, but it is well-known that while some of these are most admirably adapted for the combustion of certain coals, they are not as well suited to others and it was not possible to experiment with all of them. The question of burning powdered fuel was also considered, but the method was not adopted for the reason that it is as yet too experimental. So, in the chemical labora-

BETWEEN THE BOILERS, SHOWING DRAFT GAUGES, AND ORSAT GAS-ANALYSIS APPARATUS IN THE RIGHT FOREGROUND.

tory, much good work in the comparison of certain methods might have been accomplished, but the large number of samples to be analyzed in a comparatively short time made the adoption of accepted methods compulsory, even if the law did not.

In some of the work, which was entirely pioneer, as in the study of briquetting possibilities, some latitude had to be allowed; but this too was limited to the study of binding materials, and the various percentages of mixtures to show, if possible, a method for the practical utilization of now wasted slack or fine coals—this being consid-

ered within the intent of "determining the most economical methods for their utilization."

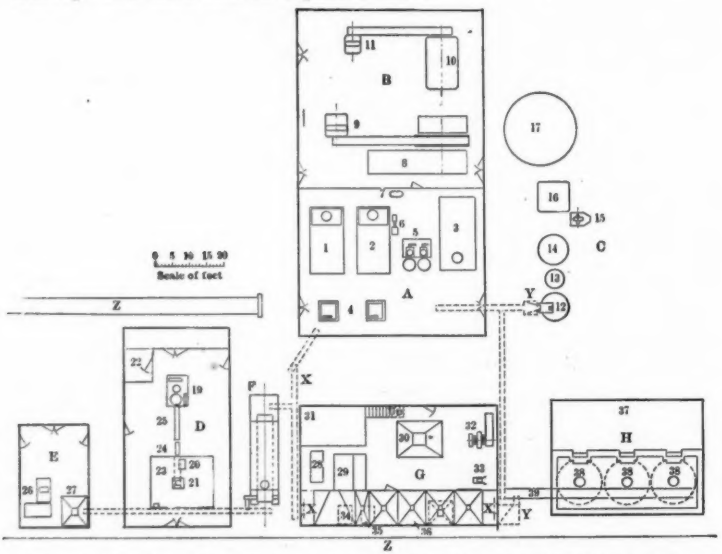
Further, it was recognized that the results of the work would be open to question unless great care was taken in the selection of the coals to be tested. Circulars were addressed to all of the coal operators in the United States from whose mines coal was shipped to market, calling attention to the proposed work, and asking if they desired to ship a carload of their product for testing, under the stipulation, in addition to free delivery, that the coal should be loaded under the personal supervision of one of the Survey's representatives. From the favorable replies received, the country was districted as impartially as possible, so that a representative collection of coals to be tested could be obtained. Mr. Campbell, who has done more work in the coal-mining regions than any other member of the Survey staff, was naturally requested to assume the important responsibility of directing this work. In addition to looking after a great deal of this field work himself, Mr. Campbell had two, and sometimes three, assistants in different parts of the country. In every case, the effort was to secure a fair representation of the colliery's output. If the market of any mine demanded screened coal, screened coal was accepted for test, but the coal was loaded from mine cars taken at random. One car of coal, substituted for the one loaded by the proper agent, remained on the side track at the testing plant untouched, until confiscated by the World's Fair Terminal Railroad for fuel.

When the plant, after a number of exasperating but unavoidable delays, was put into operation early in September, it was prepared to make tests for steam raising, producer-gas making, coke making, briquetting, and for washing, with a chemical laboratory equipped for analytical and calorimetric work. Opportunities for testing the cokes made at the plant were afforded by the "Model Foundry" located a short distance from the coal-testing plant.

The various branches of the investigation were directed by experts who stand in the front ranks of their professions. The steam-raising tests were conducted under the direction of Prof. L. P. Breckenridge, professor of mechanical engineering at the University of Illinois, with Prof. D. T. Randall, of the same institution, as chief assistant. The gas-producer operations were conducted under the supervision of Prof. R. H. Fernald, chief of the department of mechanical engineering of Washington University, St. Louis, assisted by Capt. John A. Laird, consulting engineer of St. Louis;

Prof. N. W. Lord, of the Ohio State University, assisted by Mr. E. E. Somermeier, had charge of the chemical laboratory; the briquetting tests were directed by Dr. Joseph Hyde Pratt, of the University of North Carolina, with Mr. A. A. Steel, of Omaha, Nebr., as chief assistant. The coke-oven operations were conducted by Mr. F. W. Stammler, of Johnstown, Pa., assisted by Mr. B. B. Boyd, of Uniontown, Pa. The coal-washing tests were directed by Mr. John D. Wick, of Chicago.

The plans for the buildings were prepared by, and the construction of the plant was completed under the supervision of, the Roberts & Schaefer Co., engineers, of Chicago, Ills. A full description of the plant has been published in a bulletin issued by the Geological Survey, and need not be repeated here.



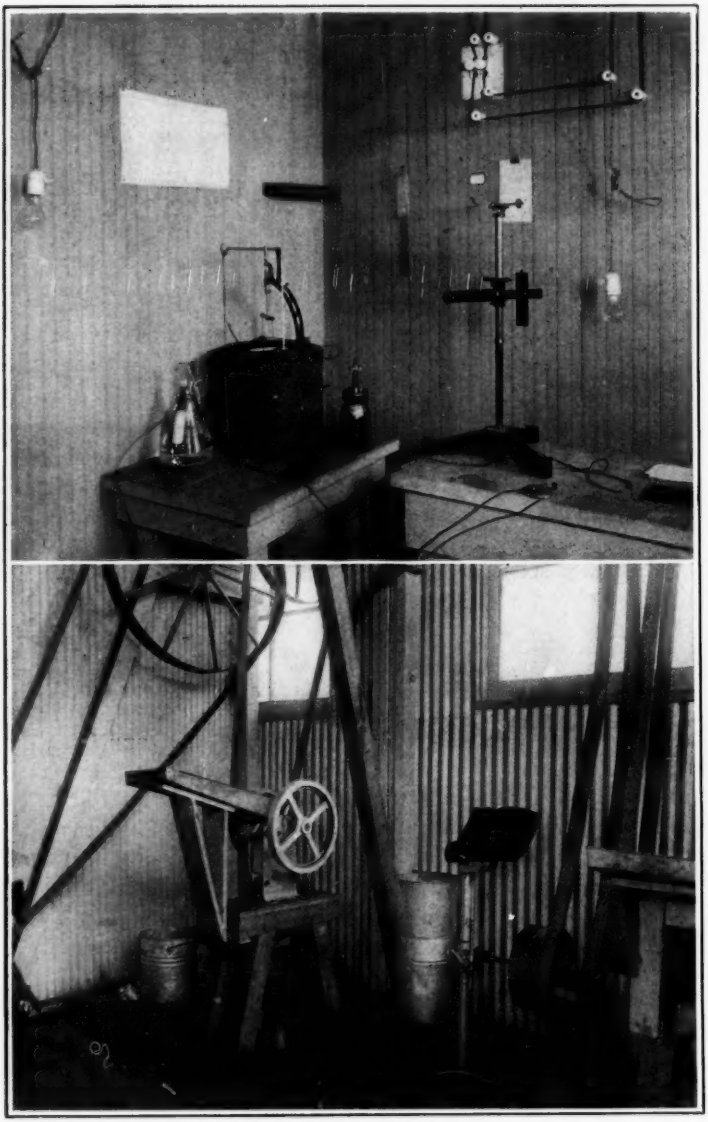
Key to the lettering:—A, Boiler house; 1 and 2, Heine boilers; 3, Frost fire-tube boiler; 4, Fairbanks coal weighing scales; 5, water ditto; 6, feed pump; 7, feed-water heater; B, Engine room; 8, 9, Allis-Chalmers-Bullock engine and belted generator; 10, 11, Westinghouse gas engine and belted generator. C, Gas-producer plant; 12, R. D. Wood & Co. producer; 13, economizer; 14, scrubber; 15, tar-extracting fan; 16, purifier; 17, gas holder. D, Briquette plant, Wm. Johnson & Sons, Leeds; 19, briquette machine; 20, pitch cracker; 21, hopper; 22, office; 23, mixer; 24, elevating fan; 25, elevator; E, Chisholm, Boyd & White briquette plant; 26, eggette machine; 27, hopper and storage bin; F, Bartlett-Snow dryer. G, washery; 28, Century jig; 29, Link Belt jig; 30, sludge tank; 31, operating platform; 32, steam engine; 33, centrifugal pump; 34, Williams mill; 35, roller crusher; 36, hoppers. H, Coke ovens; 37, wharf; 38, Laclede Firebrick Co. ovens; 39, larry track; X, Robins belt conveyors; Y, storage bins; Z, track sidings.

During the time the testing plant was in operation sixty-six carloads were received. Four of them (all from Pennsylvania) were not shipped according to the prescribed regulations and for excellent reasons. Two were shipped by the Berwind-White Coal Mining Co., and were intended for use in the locomotive tests carried on by the Pennsylvania Railroad Company. They were, however, contributed by the Berwind-White Co. to the testing plant for the purpose of drying out the boiler settings and putting the plant into running order before any testing coal was received. The first two official tests were made on these cars. One car of Connellsville coal was contributed by the H. C. Frick Co., in order that a test of the coke ovens might be made with a recognized standard coal, and the results observed and compared with a carload of Connellsville coke, also contributed by the H. C. Frick Co. These were simply for the purpose of satisfying the committee, and were not to be considered or published as official tests. The fourth car of Pennsylvania coal was anthracite culm, shipped by special request by the Hillside Coal and Iron Company, for testing in the briquetting machines.

The other sixty-two cars were received from sixteen different States, as shown in the classified list on pages 38 and 39.

It should be stated here that it was not deemed necessary to submit every coal to all the different tests. When, for instance, the laboratory determinations showed there was no tendency whatever to coke, the coal was not charged into the ovens. Moreover, as the boiler furnaces were not adapted for burning brown lignites, no steam-raising tests were made on them, the investigations on these being in the line of demonstrating the practicability of briquetting them, and for making producer gas. As will be seen by the reports on the gas-producer tests, it has been clearly shown that a superior quality of producer gas (better than that from bituminous coal) can be made from lignite, and this goes far towards solving, if it does not indeed solve, the problem of utilizing this fuel economically.

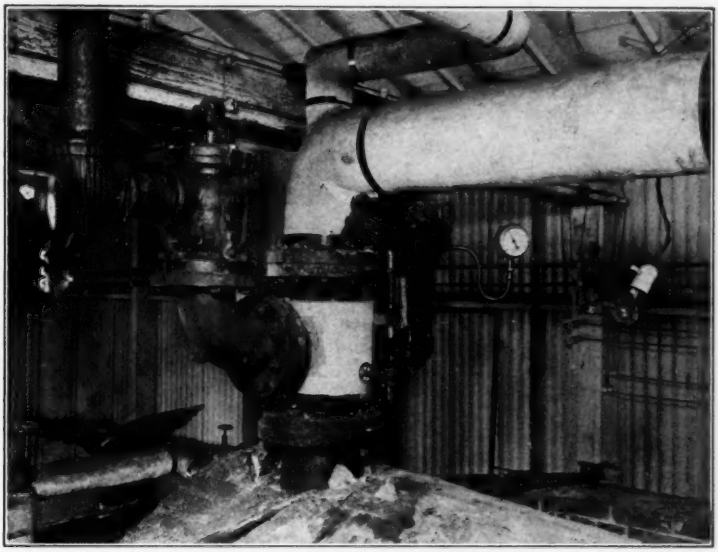
Owing to the fact that only two producer tests could be made in one week, at *any* time, and that when repairs were necessary, even this record could not be maintained, it was not possible to keep this portion of the plant co-ordinate with the boiler or steam-raising operations. Quite a number of gas-producer tests were made after January 1, 1905, the results of which will not be available until the publication of the final report, which is now in preparation. The table of comparisons showing the relative efficiency of the coals when converted into gas and used in an explosive engine, and when burned under boilers, measured by the electrical horse power developed at



PORTIONS OF THE SAMPLING AND TESTING APPARATUS. IN THE LOWER PICTURE, THE PULVERIZING MILL AND AUTOMATIC SAMPLER; IN THE UPPER ONE, THE MAHLER BOMB CALORIMETER, WITH TELESCOPE FOR READING THE THERMOMETER.

the switchboard, forms one of the most interesting features of this article, and demonstrates the importance of continued investigations along these lines.

The Chemical Laboratory.—Equal in importance with the integrity of the carload samples shipped from the mines is recognized the necessity of accurate chemical determinations based upon properly collected laboratory samples. The laboratory was equipped under the direction of Professor Lord, and was made as complete as possible. Every precaution was exercised in the collection of the samples for analysis. In the first place, two mine samples were ob-



SCHAEFFER & BUDENBERG CALORIMETER.

tained by the Survey field men, according to the rules prescribed for such work by the Geological Survey and the American Chemical Society. These samples were taken from widely separated portions of the mine, and were mailed in hermetically sealed galvanized-iron cans to the laboratory. As the car was unloaded at the plant it was carefully "sampled," and this sample was quartered down at the laboratory. As each distribution of the coal was made to the different portions of the plant for testing, this also was sampled and analyzed. Both proximate and ultimate analyses were made on car samples, and proximate analyses on the others. Calorimetric determinations (using a Mahler bomb calorimeter) were also made on

SPECIMEN ANALYSES OF MINE AND LABORATORY CAR SAMPLES OF COAL.

		Arkansas No. 3.			Arkansas No. 5.			Colorado No. 1.		
		Mine sample A.	Mine sample B.	Laboratory car sample.	Mine sample A.	Mine sample B.	Laboratory car sample.	Mine sample B.	Mine sample A.	Laboratory car sample.
Laboratory sample No.		1115	1118	1296	1130	1131	1331	1383	1397	1523
Loss of moisture on air drying		0.80	0.80	1.40	0.70	1.30	1.10	3.90	4.00	6.00
Analysis of air-dried sample.										
Proximate	Moisture	0.81	0.84	0.80	0.68	0.51	1.28	16.77	18.58	13.49
Proximate	Volatile matter	17.54	16.81	19.75	14.87	15.19	12.82	35.18	35.42	37.11
Proximate	Fixed carbon	73.68	69.59	67.65	77.45	76.94	73.69	44.29	42.38	43.03
Ultimate	Ash	7.97	12.76	11.80	7.00	7.36	12.21	3.76	3.62	6.37
Ultimate	Sulphur	1.43	1.47	1.30	1.53	1.97	2.01	0.54	0.48	0.58
Ultimate	Hydrogen	....	....	4.07	....	....	3.74	....	....	5.75
Ultimate	Carbon	....	....	76.37	....	....	77.29	....	....	61.13
Ultimate	Nitrogen	....	....	1.55	....	....	1.39	....	....	1.22
Ultimate	Oxygen	....	....	4.91	....	....	3.36	....	....	24.95
Calorific value determined:										
	Calories	7,931	....	7,586	8,017	....	7,448	5,918	....	5,995
	British thermal units	14,275	....	13,655	14,431	....	13,406	10,652	....	10,791
Calorific value calculated from ultimate analysis:										
	Calories	....	....	7,393	....	....	7,434	....	....	5,859
	British thermal units	....	....	13,307	....	....	13,381	....	....	10,546
Analysis corrected to sample as received.										
Proximate	Moisture	1.60	1.63	2.19	1.38	1.80	2.36	20.02	21.84	18.68
Proximate	Volatile matter	17.40	16.68	19.47	14.76	15.00	12.68	33.81	34.00	34.88
Proximate	Fixed carbon	73.09	69.03	66.71	76.91	75.94	72.88	42.56	40.68	40.45
Ultimate	Ash	7.91	12.66	11.63	6.95	7.26	12.08	3.61	3.48	5.99
Ultimate	Sulphur	1.42	1.46	1.28	1.52	1.94	1.99	0.52	0.46	0.55
Ultimate	Hydrogen	....	....	4.17	....	....	3.82	....	....	6.07
Ultimate	Carbon	....	....	75.31	....	....	76.44	....	....	57.46
Ultimate	Nitrogen	....	....	1.53	....	....	1.37	....	....	1.15
Ultimate	Oxygen	....	....	6.08	....	....	4.30	....	....	28.78
Calorific value determined:										
	Calories	7,868	....	7,480	7,961	....	7,366	5,687	....	5,635
	British thermal units	14,162	....	13,464	14,330	....	13,259	10,237	....	10,143
Calorific value calculated from ultimate analysis:										
	Calories	....	....	7,289	....	....	7,353	....	....	5,507
	British thermal units	....	....	13,120	....	....	13,235	....	....	9,913

one of the mine samples and on the car samples. The preliminary report of the laboratory work gives the analyses of these samples only. The analyses of the other samples are given in connection with the results of each particular test.

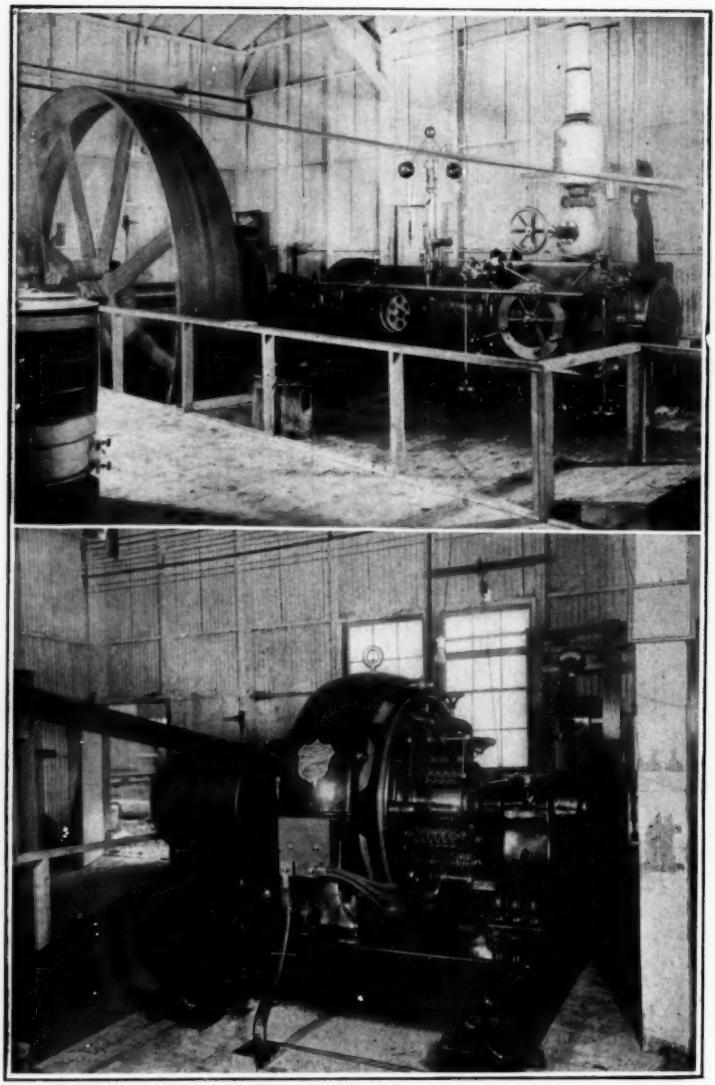
The table above gives a few of the analytical results. The complete table is too long to be printed in an article of this kind. Attention is particularly called to the very close accordance of the calorific values as shown by the calorimeter determination and by calculation from the ultimate analyses. In all but one or two instances the calculated results were very slightly less than the determined ones. Another point brought out by these analyses is the loss in moisture

SPECIMEN ANALYSES OF MINE AND LABORATORY CAR SAMPLES OF COAL.

Texas No. 1.			Texas No. 2.			West Virginia No. 1.			West Virginia No. 2.		
Mine sample B.	Mine sample A.	Laboratory car sample.	Mine sample A.	Mine sample B.	Gas-producer sample.	Mine sample B.	Mine sample A.	Laboratory car sample.	Mine sample B.	Mine sample A.	Laboratory car sample.
1195	1196	1456	1241	1243	1597	1088	1089	1213	1103	1104	1308
14.40	16.30	24.60	5.80	5.90	25.80	0.40	0.40	0.40	0.90	0.80	0.50
21.25	20.55	13.40	24.48	27.04	10.66	1.00	0.95	1.35	1.09	1.08	1.46
43.25	47.20	42.75	38.17	43.76	39.42	36.80	37.50	36.92	40.91	40.62	40.14
22.85	19.41	29.00	28.94	20.17	40.11	55.50	55.10	55.36	48.84	50.13	50.50
12.65	12.84	14.85	8.41	9.03	9.81	6.70	6.45	6.37	9.16	8.17	7.90
0.65	0.67	1.04	0.53	0.61	0.71	1.60	1.32	0.90	4.24	3.78	3.50
....	....	5.57	....	....	5.28	....	....	5.26	....	....	5.09
....	....	52.06	....	....	57.31	....	....	78.31	....	....	74.44
....	....	0.95	....	....	1.06	....	....	1.55	....	....	1.37
....	....	25.53	....	....	25.83	....	....	7.61	....	....	7.70
....	4,741	5,199	4,716	....	5,502	7,845	....	7,869	7,549	....	7,700
....	8,534	9,358	8,489	....	9,904	14,121	....	14,164	13,588	....	13,860
....	....	5,046	....	....	5,352	....	....	7,832	....	....	7,517
....	....	9,083	....	....	9,634	....	....	14,098	....	....	13,531
32.58	33.50	34.70	28.86	31.34	33.71	1.40	1.35	1.75	1.98	1.87	1.95
37.02	39.50	32.23	35.96	41.18	29.25	36.65	37.35	36.77	40.54	40.30	39.94
19.56	16.25	21.87	27.26	18.98	29.76	55.28	54.88	55.14	48.40	49.73	50.25
10.84	10.75	11.20	7.92	8.50	7.28	6.67	6.42	6.34	9.08	8.10	7.86
0.56	0.56	0.79	0.50	0.57	0.53	1.59	1.31	0.90	4.20	3.75	3.48
....	....	6.93	....	....	6.79	....	....	5.28	....	....	5.13
....	....	39.25	....	....	42.52	....	....	78.00	....	....	74.07
....	....	0.72	....	....	0.79	....	....	1.54	....	....	1.36
....	....	41.11	....	....	42.09	....	....	7.94	....	....	8.10
....	3,968	3,920	4,442	....	4,082	7,813	....	7,837	7,481	....	7,661
....	7,142	7,056	7,996	....	7,348	14,063	....	14,107	13,466	....	13,790
....	....	3,805	....	....	3,975	....	....	7,800	....	....	7,480
....	....	6,849	....	....	7,155	....	....	14,040	....	....	13,464

by air-drying. This loss in some bituminous coals was as high as 10 per cent., and in the case of Texas lignites, 25 per cent. Still another interesting feature is the difference in ash shown between the mine samples and the car samples, although in taking the samples at the mine every effort was made to secure a fair representation. In almost every case the car samples show a higher percentage of ash, the average excess being 2.5 per cent. for all analyses.

The "general number," such as Arkansas No. 3, etc., in this table, and subsequent ones, is given for identification with the list showing the mine and State from which each coal was shipped.



ALLIS-CORLISS ENGINE, 210 HORSE POWER, AND BULLOCK 250-VOLT DIRECT-CURRENT GENERATOR. USED IN THE STEAM-GENERATING TESTS.

Steam-Raising Tests.—The entire equipment of the steam-generating plant was installed in a building made of corrugated iron, nailed to a wooden framework. The building occupies a floor space of 2,300 square feet, and is divided into two parts by a partition, the boilers and other apparatus for steam-raising tests being in one room, the engines (steam and gas) and the generators in the other. The tests have all been made in the Heine boilers, which had entirely separate settings, so that trials could be run on one, while the other was being overhauled and cleaned. The boilers are of the following dimensions:—

Grate surface .....square feet..	40.55
Width of grate.....feet..	6.16
Length of grate .....do...	6.58
Height of furnace .....inches..	26
Approximate width of air spaces in grate.....do....	.5
Proportion of air space to whole grate surface....per cent..	44
Area of chimney.....square feet..	7.67
Height of chimney above grate.....feet..	113.25
Length of flue connecting chimney.....feet, direct.....	0
Kind of draft	Chimney.
Water-heating surface .....square feet..	2,031
Outside diameter of shell.....inches	42.9
Length of shell (outside to outside of heads).....feet..	21.6
Number of tubes	116
Diameter of tubes:	
Outside .....inches..	3.5
Inside .....do...	3.25
Length of tubes .....feet..	17.87
Superheating surface .....square feet..	0
Ratio of water-heating surface to grate surface.... — to 1..	50.1

The testing equipment used in the boiler trials consist of water-weighing tanks and scales, coal-weighing car and scales, calorimeters, thermometers, and pyrometers, draft gauges, and gas sampling and analyzing apparatus.

The duration of each trial was as nearly as possible ten hours, keeping in view only that at the beginning and the end of the tests the conditions of the fire should be as near alike as could be judged.

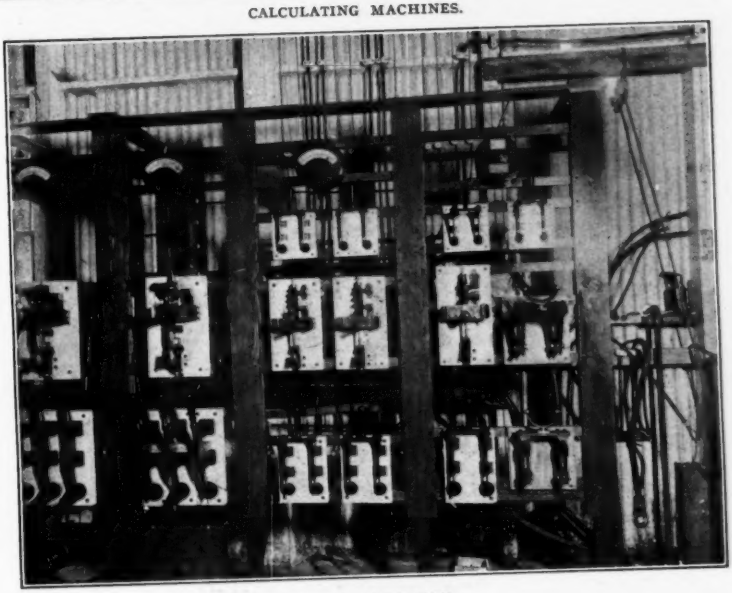
The object of the tests was to make boiler trials and to burn various coals under some standard boiler, and under what might be called fair conditions. Usually but a single trial could be made with each coal. In all the trials an effort has been made to maintain the rated horse power of the boiler in use.

The tests have been made in accordance with the code of the American Society of Mechanical Engineers.

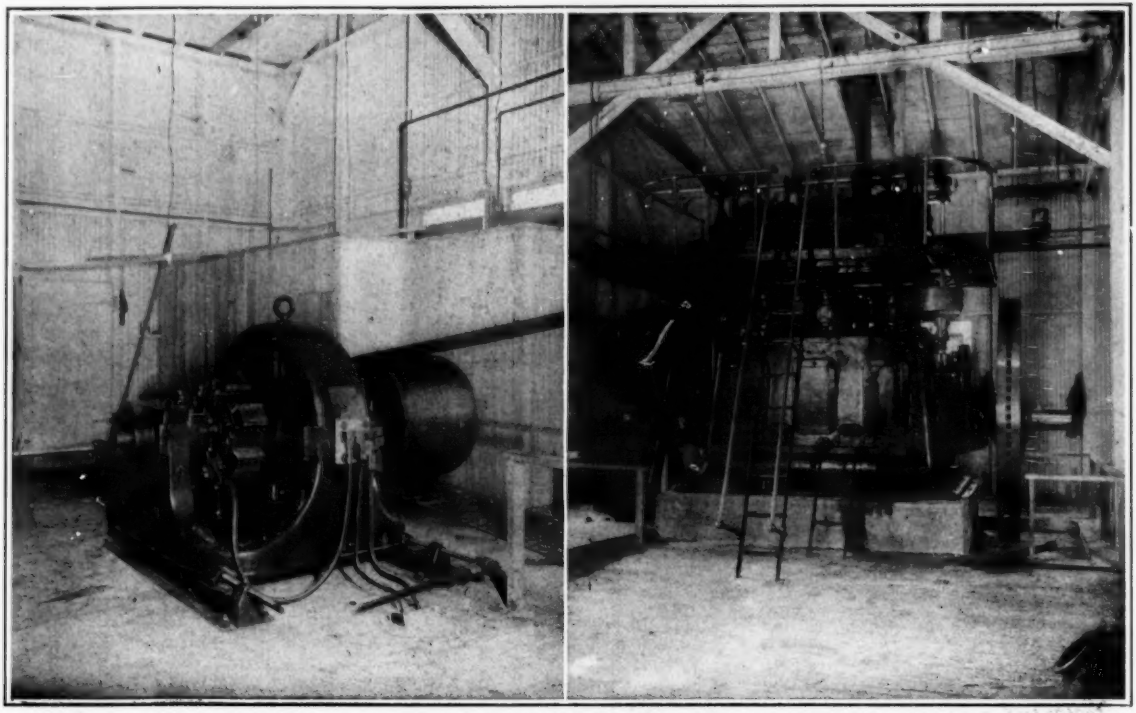
TABLE OF RESULTS OF COAL TESTS UNDER BOILERS.

Name of Sample.	Analysis of boiler-room sample.					Results.						
	Fixed carbon.	Volatile matter.	Moisture.	Ash.	Sulphur determined separately.	Duration of trial.	Total coal consumed.	Horse power developed by boiler.	Dry coal burned per sq. ft. grate surface per hour.	Equivalent evaporation from and at 212° F. per pound of dry coal.	Dry coal per indicated horse power hour.	Dry coal per electrical horse power hour.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Hours.	Lbs.		Lbs.	Lbs.	Lbs.	Lbs.
1	2	3	4	5	6	7	8	9	10	11	12	13
Alabama 1.....	52.52	31.00	2.56	13.92	.78	10.03	8,656	205.8	20.72	8.44	3.35	4.14
do. briquetted	50.96	33.00	2.63	13.41	.94	8.25	6,521	196.6	18.97	8.81	3.21	3.96
Alabama 2.....	48.65	32.98	4.83	13.54	1.17	10.02	9,198	216.4	21.54	8.55	3.31	4.08
Arkansas 1.....	66.36	18.61	1.99	13.04	1.21	10.07	7,071	180.5	16.90	9.05	3.12	3.86
do. briquetted	67.65	21.21	.94	10.20	1.73	10.03	7,700	206.4	18.74	9.37	3.02	3.73
Arkansas 2.....	73.65	16.86	1.07	8.42	1.95	10.07	6,517	180.6	15.70	9.73	2.91	3.59
do. briquetted	60.30	22.49	4.88	12.33	1.32	9.98	7,370	190.3	17.31	9.31	3.00	3.71
Arkansas 3.....	72.74	16.04	1.97	9.25	1.29	10.02	8,158	219.7	19.68	9.50	2.98	3.68
do. briquetted	62.04	17.35	2.60	18.01	1.41	10.08	8,600	200.8	20.49	8.34	3.39	4.19
do. 4, briq...	71.98	14.06	3.85	10.11	1.04	9.95	8,142	214.5	19.41	9.40	3.01	3.72
do. small do...	66.03	18.60	3.18	12.19	1.70	7.03	5,238	166.8	17.78	7.98	3.54	4.38
Arkansas 5.....	73.68	12.54	2.22	11.56	2.39	10.13	9,000	202.4	21.42	8.04	3.52	4.34
Colorado 1.....	39.00	35.85	19.78	5.37	.42	9.97	8,972	151.0	17.80	7.21	3.92	4.85
Illinois 1.....	38.21	36.91	9.69	15.19	4.40	9.93	11,124	211.4	24.90	7.21	3.92	4.85
do. 2, washed	41.72	37.77	10.45	10.06	3.36	9.97	10,096	210.2	22.36	8.00	3.54	4.38
Illinois 3.....	48.75	31.19	8.51	11.55	1.5	10.13	9,537	200.6	21.23	8.04	3.52	4.34
Illinois 4.....	41.59	33.48	13.47	11.46	1.28	10.07	9,367	172.0	19.84	7.37	3.83	4.73
do. 4, 2d test	43.63	32.44	12.58	11.35	1.36	10.02	10,750	197.8	23.13	7.27	3.89	4.8
Illinois 6.....	39.62	32.31	13.19	14.88	3.48	9.92	10,343	194.3	22.34	7.4	3.82	4.72
Indiana 1, briq.	43.23	38.79	11.74	6.24	2.03	6.6	6,579	222.6	21.7	8.73	3.24	4.00
do. washed..	40.41	35.17	16.59	7.83	2.18	9.93	10,819	222.7	22.39	8.45	3.34	4.13
Indiana 2.....	40.40	38.04	9.11	12.45	4.12	10.13	9,274	193.4	20.51	8.02	3.53	4.35
Indian Ter. 1...	46.30	33.96	7.65	12.09	1.8	9.75	8,210	194.7	19.17	8.64	3.27	4.04
Indian Ter. 2...	50.31	36.21	3.71	9.77	1.39	10.17	9,213	212.9	21.5	8.42	3.36	4.15
Indian Ter. 3...	47.58	37.3	4.79	10.33	3.93	10.02	9,145	205.9	21.43	8.17	3.46	4.27
Indian Ter. 4...	45.33	35.44	6.24	12.99	3.86	10.22	9,296	186.1	21.04	7.53	3.76	4.64
Iowa 1.....	39.80	33.08	8.69	18.34	6.39	10.02	10,331	197.7	23.23	7.24	3.91	4.82
Iowa 2.....	33.73	35.35	14.88	16.04	4.73	9.92	10,986	192.7	23.28	7.05	4.01	4.95
Iowa 3.....	35.77	36.14	12.44	15.65	6.07	10.03	10,668	189.3	22.96	7.02	4.03	4.97
Iowa 4, briq...	37.85	36.50	13.24	12.41	3.90	10.03	9,900	184.5	21.11	7.43	3.80	4.70
Iowa 5.....	38.83	31.76	16.01	13.40	3.09	9.98	11,200	204.7	23.23	7.50	3.77	4.60
Kansas 1.....	49.46	33.78	5.90	10.86	3.82	10.10	7,222	158.2	16.60	8.11	3.49	4.31
Kansas 1.....	48.57	32.68	4.80	13.95	4.94	9.70	7,492	184.	18.13	8.63	3.28	4.05
Kansas 2.....	46.68	31.23	4.18	17.91	6.27	7.00	5,600	181.5	18.90	8.17	3.46	4.28
do. washed..	51.22	34.32	5.82	8.64	3.77	9.38	8,111	200.8	20.08	8.89	3.18	3.93
Kansas 3.....	50.99	33.52	2.03	13.46	5.39	9.91	7,700	169.6	18.77	7.69	3.68	4.55
do. 2d test	51.05	34.30	2.25	12.40	4.80	10.40	7,101	148.8	16.45	7.69	3.68	4.55
Kansas 4.....	43.59	36.32	5.51	14.58	8.46	10.05	7,835	165.5	18.18	7.75	3.65	4.51
Kentucky 1.....	55.59	35.61	2.89	5.91	1.19	10.03	8,355	212.3	19.95	9.06	3.12	3.86
Kentucky 2.....	45.75	37.91	7.76	8.58	3.37	10.00	9,557	208.5	21.75	8.16	3.47	4.28
do. briq..	44.32	37.07	7.11	11.50	3.71	9.82	9,371	207.1	21.87	8.06	3.51	4.33
Kentucky 3.....	44.84	37.32	7.92	9.92	3.91	10.07	9,645	211.5	21.75	8.27	3.42	4.22
Kentucky 4.....	45.74	35.65	5.89	12.72	3.72	9.93	9,386	211.7	21.90	8.21	3.44	4.25
Missouri 1.....	40.64	34.88	7.28	17.20	4.37	10.00	9,737	207.4	22.30	7.92	3.57	4.41
do. briq..	41.85	37.60	6.38	14.17	4.56	5.10	4,500	191.2	20.37	7.99	3.54	4.37
do. washed	44.21	36.81	7.93	11.05	3.58	9.91	9,041	207.0	20.71	8.50	3.33	4.11
Missouri 2.....	37.33	32.88	13.09	16.70	4.92	9.98	11,650	208.2	25.00	7.08	3.99	4.93
do. 2d test.	39.76	31.77	11.57	16.90	4.60	9.98	9,248	172.5	20.20	7.26	3.90	4.81
Missouri 3.....	29.98	26.18	18.63	25.21	3.85	9.95	10,828	149.5	21.85	5.82	4.86	6.00
do. washed	39.61	31.18	20.78	8.43	2.88	9.93	11,044	180.7	21.72	7.43	3.81	4.70
Missouri 4.....	42.11	40.10	12.24	5.55	4.98	9.98	9,515	214.1	20.64	8.83	3.20	3.96
New Mexico 1..	41.57	37.85	11.90	8.68	.56	10.05	10,963	206.3	23.70	7.41	3.96	4.90
New Mexico 2..	36.11	37.30	9.92	16.67	1.13	10.00	11,870	198.5	26.37	6.41	4.41	5.45
do. briq.	39.97	37.56	6.75	16.62	1.01	8.12	7,765	185.8	22.00	7.19	3.93	4.86
North Dakota 1.	25.40	28.13	35.84	10.63	1.68	9.85	10,680	108.9	17.15	5.40	5.24	6.47
Pennsylvania 1.	75.69	15.80	1.10	7.41	1.49	9.88	6,365	166.9	15.70	9.04	3.11	3.84
Pennsylvania 2.	76.76	16.61	.59	6.04	.91	10.08	6,835	191.2	16.60	9.79	2.89	3.57
do. 3, briq.	55.00	27.62	3.00	14.38	1.13	10.08	8,012	184.5	19.01	8.26	3.42	4.23
West Virginia 1.	56.25	34.64	1.90	7.21	.98	9.98	7,818	199.2	18.94	8.95	3.16	3.90
West Virginia 2.	48.80	39.23	2.01	9.96	2.71	10.22	8,354	212.4	19.75	9.14	3.09	3.82
West Virginia 3.	56.11	30.31	2.54	11.04	1.38	9.97	8,225	211.6	19.82	9.08	3.11	3.84
West Virginia 4.	59.84	27.64	2.53	9.99	.96	10.00	7,895	215.1	18.98	9.65	2.93	3.62
West Virginia 5.	58.66	28.95	2.11	10.28	1.01	10.08	7,700	207.8	18.44	9.59	2.95	3.81
West Virginia 6.	70.03	22.38	2.14	5.45	.70	9.95	7,406	213.2	17.95	10.09	2.80	3.46
do. 2d test	71.42	21.44	2.11	5.03	.64	10.18	7,264	208.5	17.21	10.30	2.74	3.39
West Virginia 7.	68.27	20.25	2.68	8.82	1.52	10.18	7,700	210.1	18.15	9.85	2.87	3.55
West Virginia 8.	56.68	31.19	5.26	6.87	.74	9.98	7,997	211.6	18.72	9.62	2.94	3.63
West Virginia 9.	59.47	31.11	3.42	6.00	.82	10.00	7,464	210.8	17.78	10.09	2.80	3.46
West Virginia 10	73.84	18.23	1.74	6.19	.59	9.93	7,441	205.9	18.15	9.65	2.93	3.62
West Virginia 11	68.36	16.31	4.85	10.48	.47	9.97	7,700	213.7	18.13	10.03	2.82	3.48
West Virginia 12	75.33	18.26	1.58	4.83	.59	10.13	7,399	206.1	17.68	9.90	2.86	3.53
do. 2 briq.	67.46	24.02	2.32	6.20	.84	10.25	7,515	211.8	17.66	10.20	2.77	3.42
Wyoming 1....	31.61	40.56	21.81	6.02	.63	10.15	11,946	186.6	22.69	7.00	4.04	4.99
Wyoming 2....	34.58	35.55	11.10	18.77	3.87	9.95	12,028	184.3	26.51	5.92	4.77	5.90

CALCULATING MACHINES.

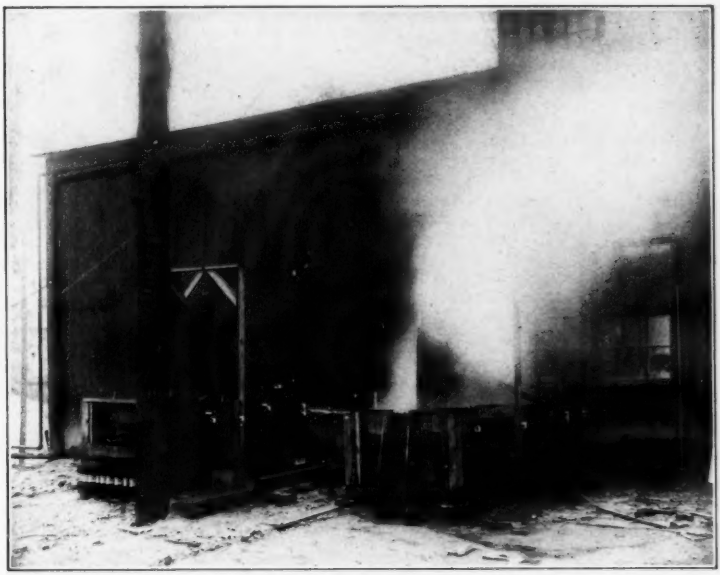


THE SWITCHBOARD.



WESTINGHOUSE 235-BRAKE-HORSE-POWER THREE-CYLINDER GAS ENGINE AND 250-VOLT DIRECT-CURRENT GENERATOR. USED IN THE GAS-PRODUCING TESTS.

A brief summary of the results obtained in the steam-generating tests is given in the table on page 34. It will be noted that there were eight tests of briquettes (three of Arkansas coals, one of Alabama, one of Kentucky, one of Missouri, one of New Mexico, and one of West Virginia), which may be compared with tests of the coal from which the briquettes were made. In five of these instances the fuel consumption per electrical horse power developed was in favor of the briquettes, and in three it was in favor of the coal unbriquetted.



THE WATER RHEOSTATS.

In three cases, where tests were made of washed coal, the results were all substantially favorable to the washed fuel. In one case, particularly, that of Missouri No. 3, the fuel consumption per electrical horse power was reduced from 6 pounds for the unwashed coal to 4.7 pounds for the washed coal. The ash contents of the coal were reduced by washing from 25.21 per cent. to 8.43 per cent.

Space limitations compel an intermission at this point. In a succeeding number of THE ENGINEERING MAGAZINE will be presented the gas-producing, coking, and briquetting tests, with their results concisely tabulated and the steam-generating and gas-producing efficiencies of the fuels comparatively presented; and with these will be the experiments with various binders for briquetted fuels.

LIST OF CAR SAMPLES OF COAL TESTED DURING THE SEASON OF 1904 AT THE U. S. GEOLOGICAL SURVEY FUEL-TESTING PLANT AT THE LOUISIANA PURCHASE EXPOSITION.

Alabama.

No. 1. Lump and nut coal from mine No. 8 of the Ivy Coal & Iron Co., located at Horse Creek, Ala.

No. 2. Lump, nut and pea coal from mine No. 5 of the Galloway Coal Co., located at Carbon Hill, Ala.

Arkansas.

No. 1. Lump and nut coal from mine No. 3 of the Central Coal & Coke Co., located at Huntington, Ark.

No. 2. Lump coal from mine No. 12 of the Central Coal & Coke Co., located at Bonanza, Ark.

No. 3. Lump and slack coal from mine No. 18 of the Western Coal & Mining Co., located at Jenny Lind, Ark.

No. 4. Slack coal from several Arkansas mines furnished by the Union Fuel Co., St. Louis, Mo.

No. 5. Lump and slack coal from mine No. 4 of the Western Coal & Mining Co., located at Coal Hill, Ark.

No. 6. Slack coal from mine No. 18 of the Western Coal & Mining Co., located at Jenny Lind, Ark.

Colorado.

No. 1. Run-of-mine black lignite from Simpson mine of the Northern Coal & Coke Co., located at Lafayette, Colo.

Illinois.

No. 1. Lump and nut coal from mine No. 1 of the Western Anthracite Coal & Coke Co., located near O'Fallon, Ill.

No. 2. Slack coal from same as Illinois No. 1.

No. 3. Run-of-mine coal from mine No. 3 of the Southern Coal Mining & Washing Co., located near Marion, Ill.

No. 4. Lump coal from mine No. 3 of the Donk Bros. Coal & Coke Co., located at Troy.

No. 5. Washed slack from mine No. 1 of Donk Bros. Coal & Coke Co., located near Collinsville, Ill.

No. 6. Run-of-mine coal from shaft No. 1 of Clover Leaf Coal Co., located at Coffeen, Ill.

Indian Territory.

No. 1. Lump and slack coal from mine No. 1 of the Whitehead Coal & Mining Co., located at Henryetta, I. T.

No. 2. Run-of-mine coal from mine No. 8 of the Rock Island Coal Co., located at Hartshorne, I. T.

No. 3. Run-of-mine coal from mine No. 1 of D. Edwards & Son, located at Edwards, I. T.

No. 4. Lump coal from mine No. 5 of the Western Coal & Mining Co., located at Lehigh, I. T.

No. 5. Slack and pea coal from mine No. 7 of the Western Coal & Mining Co., located at Lehigh, I. T.

No. 6. Slack coal from Southwestern Development Company's mines at Coalgate, I. T.

Indiana.

No. 1. Run-of-mine coal from Mildred mine of the J. Wooley Coal Co., located at Mildred, Ind.

No. 2. Run-of-mine coal from Electric mine of the T. D. Scales Coal Co., located at Boonville, Ind.

Iowa.

No. 1. Lump and fine coal from mine No. 2 of the Anchor Coal Co., located at Laddsdale, Ia.

No. 2. Run-of-mine coal from mine No. 6 of the Mammoth Vein Coal Co., located at Hamilton, Ia.

No. 3. Lump coal from mine No. 4 of the Gibson Coal Mining Co., located near Altina, Ia.

No. 4. Lump coal from mine No. 3 of the Centerville Block Coal Co., located at Centerville, Ia.

No. 5. Run-of-mine coal from Inland mine No. 1 of the Inland Fuel Co., located at Chariton, Ia.

Kansas.

No. 1. Coal from mine No. 10 of the Western Coal & Mining Co., located at Fleming, Kans.

No. 2. Lump, nut, and slack from mine No. 11 of the Western Coal & Mining Co., located at Yale, Kans.

No. 3. Run-of-mine coal from mine No. 9 of the Southern Coal & Mercantile Co., located at Scammon, Kans.

Kansas.

No. 4. Lump coal from mine of the Atchison Coal Mining Co., located at Atchison, Kans.

No. 5. Lump and nut coal from mine No. 11 of the Southwestern Development Co., located at West Mineral, Kans.

Kentucky.

No. 1. Run-of-mine coal from Straight Creek mine No. 2 of the National Coal & Iron Co., located at Straight Creek, Ky.

No. 2. Lump, nut, pea, and slack coal from mine No. 1 of the St. Bernard Mining Co., located at Earlington, Ky.

No. 3. Run-of-mine coal from Bramsley mine of the St. Bernard Mining Co., located nead Earlington, Ky.

No. 4. Run-of-mine coal from mine of the Wheatcroft Coal & Mining Co., located at Wheatcroft, Ky.

Missouri.

No. 1. Run-of-mine coal from New Home mine No. 1 of the New Home Coal Co., located at Sprague, Mo.

No. 2. Run-of-mine coal from mine No. 8 of the Northwestern Coal & Mining Co., located near Bevier, Mo.

No. 3. Slack coal from mine of the Mendota Coal & Mining Co., located near Mendota, Mo.

No. 4. Run-of-mine coal from mine of Morgan County Coal Co., located near Barnet, Mo.

Montana.

No. 1. Washed nut coal from mine near Red Lodge, Mont.

New Mexico.

No. 1. Lump and slack coal from Weaver mine of the American Fuel Co., located three miles north of Gallup, N. M.

No. 2. Slack coal from Otero mine of the Caledonian Coal Co., located two miles east of Gallup, N. M.

North Dakota.

No. 1. Run-of-mine brown lignite from Lehigh, N. D.

No. 2. Run-of-mine brown lignite from mine of the Cedar Coulee Coal Co., located four miles southeast of Williston, N. D.

Texas.

No. 1. Brown lignite from mine of the Houston County Coal & Mfg. Co., located eleven miles south of Crockett, Tex.

No. 2. Brown lignite from Consumers' Lignite Co., located at Hoyt, Tex.

West Virginia.

No. 1. Run-of-mine coal from mine of the Virginia & Pittsburg Coal Co., located at Kingmont, W. Va.

No. 2. Run-of-mine coal from Pitcairn Mine of the Pitcairn Coal Co., located at Clarksburg, W. Va.

No. 3. Run-of-mine coal from mine of West Virginia Coal Co., located at Richard, W. Va.

No. 4. Run of-mine coal from mine of the West Virginia Coal Co., located at Bretz, W. Va.

No. 5. Lump and nut coal from mine of the Davis Colliery Co., located at Coalton, W. Va.

No. 6. Run-of-mine coal from mine of the New River Smokeless Coal Co., located at Rush Run, W. Va.

No. 7. Run-of-mine coal from mine of the New River Smokeless Coal Co., located at Sun Switch, W. Va.

No. 8. Run-of-mile coal from mine of the Gauley Mountain Coal Co., located at Ansted, W. Va.

No. 9. Run-of-mine coal from Vulcan mine of the Mt. Carbon Company, Ltd., located at Powellton, W. Va.

No. 10. Lump and run-of-mine coal from mine of the Sagamore Colliery Co., located at Mora, W. Va.

No. 11. Run-of-mine coal from mines Nos. 1 and 2 of the W. H. Coffman Coal & Coke Co., located at Zenith, W. Va.

No. 12. Run-of-mine coal from mine of the Big Sandy Coal & Coke Co., located at Big Sandy, W. Va.

Wyoming.

No. 1. Black lignite from mine of the Wyoming Coal & Mining Co., located at Monarch, Wyo.

No. 2. Black lignite from mine of the Cambria Fuel Co.

THE COST SYSTEM OF AN ENGINEERING WORKS.

By H. Deighton.

In point of comprehensive provision for cost keeping, stock tracing, stores control, and general accounting, the system described by Mr. Deighton appears one of the most effective we have published. And with its efficiency it combines great practicability and simplicity.—The Editors.

THE engineering works in which the cost system herein described is in operation has been chosen as being one in which the conditions were unusually favorable for the installation and successful operation of a complete system. The general organization and accounting are also incidentally referred to.

Here are built large stationary engines as well as small machines, the parts of which have been standardized as far as possible. Considerable jobbing work, a good deal of which is in the form of repairs, is also done. The company has no foundry of its own, all brass, iron, and other castings being purchased from nearby foundries. On an average, something like 800 hands are employed in the works, about 30 per cent. of whom are piece workers, and the remainder day workers. In addition, about 50 men are employed on the road, who are engaged chiefly in erecting engines and making repairs.

There are in the factory nine productive and partially productive departments. In order to distinguish these more clearly from the non-productive departments, such as the store house, the power plant, etc., they will be referred to in the following as the "productive" departments. Department numbers have been allotted to each of them, which are:—

Blacksmith's shop	Department No.	1
Carpenter's shop	" "	2
Pattern shop	" "	3
Boiler shop	" "	4
Tool room	" "	5
Large machine shop	" "	6
Small machine shop	" "	7
Assembling room	" "	8
Erecting shop	" "	9

There is a department foreman in each of these, and also a department clerk who is employed chiefly in the making out of time slips

and piece-work vouchers, ordering of material, keeping track of orders, and doing any other clerical work, and occasionally some other duties. The storehouse is located as centrally as possible, in order to avoid any unnecessary handling of material. Here is the store-keeper's office, Adjoining it is the superintendent's office. The secretary of the company, who is in charge of the general office or accounting department, also supervises the cost system and other clerical work of the factory.

Little need be said about the general books in the accounting department, which are concise and up-to-date. They consist chiefly of the following: Petty cash book, bank cash book, purchase journal, sales journal, general journal, general ledger. There is nothing unusual about any of these except the sales journal, a reduced copy of which is illustrated by Form No. 10. At the extreme left will be noticed two additional columns headed "Trading a/c" and sub-headed "Stores" and "Manufacturing," into which cost prices are entered. These are used in connection with the monthly revenue account and balance sheet, and will be again referred to.

The purchase ledger and the sales ledger are subsidiary books, represented by controlling accounts in the general ledger. The cost ledgers, which are subsidiary ledgers, are kept in the accounting department, and are controlled by the "Manufacturing" account in the general ledger. The stores ledgers, too, are subsidiary, and controlled by the "Stores" account in the general ledger. They are, however, kept in the store-house.

Shipping orders emanate from the sales department, and bear consecutive numbers. Before going to the shipping clerk they pass through the superintendent's office, where inquiry is made as to whether the goods are in stock or have to be made specially in the factory; which information is noted on them for the guidance of the shipping clerk. If the goods are in stock, the shipping clerk draws them out of the storehouse on stores warrants (see Form No. 6). If they have to be made specially, they will, when ready, be delivered to him by one of the productive departments, shop orders (see Form No. 2) having in the meantime been issued from the superintendent's office instructing the foremen of the different departments interested.

On executing a shipping order, the shipping clerk turns it in to the accounting department. After the selling prices have been noted on it by the sales department, it forms, in the hands of the billing clerk, the basis of an invoice to the customer. Shipping orders are consecutively numbered before being issued, and as a hard-and-fast rule has been laid down and is strictly adhered to that no goods what-

soever must leave the factory except in execution of written shipping orders, it tends to eliminate the possibility of any omission to bill goods, and moreover facilitates the auditing of the sales journal.

The shop order used is illustrated by Form No. 2, which has been reduced in size. These are thin cards, and are issued only from the superintendent's office, as instruction to the department foremen. They are all consecutively numbered as issued, and specify fully the work to be done, give reference to the drawing number and piece or pattern number, and state where the goods must be delivered.

PAY ROLL FOR WEEK ENDING

Dept. No. 190

Man No.	NAME	S.	M.	T.	W.	T.	F.	S.	Total Hrs.	Rate	Amount		Remarks

The Engineering Magazine

FORM I. PAY ROLL. REDUCED SIZE.

Sometimes all the work on a shop order can be done in one department, in which case an order is issued to that foreman only. But in most cases the work has to be done in more than one department, thus necessitating the issuing of more than one shop order. Of course these all bear the same number, and only such instructions are given to each foreman as necessarily concern him. As the work is passed on by one department to another, the recipient signs for it on the back of the shop order, which is immediately returned to the superintendent's office. On issuing a shop order, a course tag (see Form No. 3), on which is noted the shop-order number and brief description of the article or work, is also issued to the foreman of the first department engaged on it. This tag is attached to one of the articles and accompanies it throughout its course, till the work is finished and delivered to the store keeper or the shipping clerk, thus affording a means by which work in progress can be readily identified at all times.

Instructions have been issued that no work must be done in the factory except in execution of written shop orders, which rule is kept

as hard-and-fast as possible; still there are a few exceptions, such as in the case of a blacksmith or tool maker tempering or repairing tools, or doing other similar petty jobs which take less than say ¼ hour's time, or in the case of a floor sweeper or general laborer, whose time is always indirect. These exceptions, however, and the extent of them, have been pretty well defined and are clearly understood throughout the works.

Shop orders are divided into three classes, for each of which a separate series of numbers has been reserved, so as to distinguish them more clearly. They are: "Personal" shop orders, "Stock" shop orders, and "Plant" shop orders.

SHOP ORDER No.

_____ 190 ____

Mr. _____ Foreman of Dept. No. _____

Please do work as specified below. Deliver to _____

Charge all time and material to above Order No.

_____

Superintendent

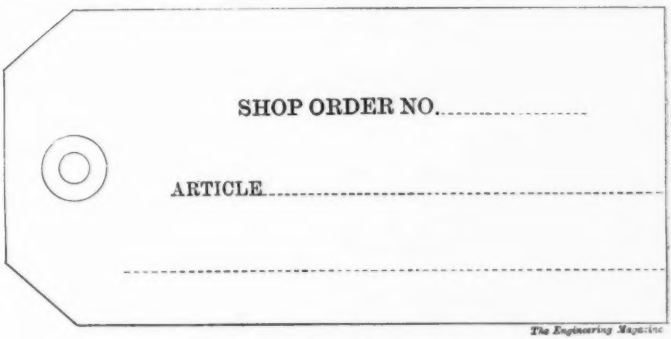
On execution of this order it must be immediately returned to the Superintendent's Office

Work Completed _____ 190 _____

Foreman

The Engineering Magazine

FORM 2. SHOP ORDER. REDUCED SIZE.



FORM 3. COURSE TAG. FULL SIZE.

"Personal" shop orders are issued in execution or partial execution of shipping orders, the work being done specially for some customer,

and on completion delivered to the shipping clerk. These always bear the same number as the shipping order, though if the shipping order calls for two or more entirely different articles, separate costs of which are desired, two or more shop orders are issued, the numbers of which are further distinguished; as for instance, No. 1706—1, and No. 1706—2, which two shop orders are issued on account of shipping order No. 1706.

"Stock" shop orders are issued to produce articles for stock, which on completion are delivered to the store keeper.

"Plant" shop orders are issued to produce new articles of plant and equipment, make repairs and alterations, or do any other work which partakes of the nature of an expense around the factory. It is left to the accounting department to determine whether the cost of these is a charge to capital or to revenue, and to which accounts.

In order that the superintendent and his clerk may keep proper track of all work in progress in the factory, the following system has been devised:—There is in the superintendent's office a card case which is in the form of an open sloping frame. It is divided into three sections, one for each of the different classes of shop orders. Immediately a shop order is issued, a copy of it is made out and inserted in this card frame. If it is issued to more than one department, the card for the frame gives only a brief description of the work, and states at the top which of the departments have been instructed. Each card remains in the card frame till the order it represents is finished, when it is taken out and filed away. As soon as a foreman finishes his portion of the work and delivers it to the next department, he returns his shop-order card to

DAILY TIME SLIP

.....190.....

Dept. No.

Name

Description of Work

Shop Order No.

	Hours	Rate	Amount	
Workman No.				
" " Overtime				
Machine Tool No.				
" " "				
" " "				

The Engineering Magazine

FORM 4. DAILY TIME SLIP. ORIGINAL IS 3½ BY 5½ INCHES.

the superintendent's office, where it is also deposited in its proper place in the card frame. This enables the superintendent or his clerk to tell immediately, without leaving the office, in which department an order is being worked on at any time, and thus have some idea as to how near completion it is.

Each workman on being hired is allotted a register number. On entering and leaving the factory he registers his time at the gate by means of an automatic time-recording clock, of which there are several good kinds in the market, which are fast superseding the old-fashioned method of registering by using brass checks. From the records of this register the numbers of hours put in by each man each day is credited to him daily on the weekly pay-roll (see Form No. 1); the cross footing of these hours at the end of the week gives his total number of hours, which multiplied by his rate, brings the amount of his pay for the week. When a man works overtime two lines are used for him, as the overtime is figured at an increased rate per hour. The time so recorded, though taken as evidence of presence at work, is further verified as explained below. Separate pay rolls are made up for each department. The same form of pay roll is used for piece workers, each man's number of hours each day being filled in, but the amounts credited are obtained from the piece-work vouchers turned in. (See Form No. 5.)

PIECE WORK VOUCHER

190

Dept No. Workman No.

Name

Operation

Quantity

Article

Piece or Pattern No.

Shop Order No.

	Quantity Done	Rate	Amount	

Finished 190

Inspector

Foreman

The Engineering Magazine

FORM 5. PIECE-WORK VOUCHER. ORIGINAL IS 3½ BY 5½ INCHES.

No ledger accounts are kept with the workmen, nor do advances to piece workers on account of unfinished piece work appear on the pay roll; such payments are considered as loans, and small specially printed I. O. U. cards made out for them, O. K.'d by the superintendent. These the cashier surrenders to the men through the paymaster for the refund of the money so advanced on pay days.

STORES WARRANT NO.

Please deliver material as below
To be used for _____ 190 _____
_____ Order No. _____ _____ Foreman

Quantity	DESCRIPTION	Weight	Rate	Amount		Stores Led. Fo.

Received by _____ 190 _____

The Engineering Magazine

FORM 6. STORES WARRANT. ORIGINAL IS ABOUT 5½ BY 4 INCHES.

STORES DEBIT NOTE NO.

Please receive into store material as below
From Shop Order No. _____ _____ 190 _____
_____ Foreman

Quantity	DESCRIPTION	Weight	Rate	Amount		Stores Led. Fo.

Received by _____ 190 _____

The Engineering Magazine

FORM 7. STORES DEBIT NOTE. ORIGINAL IS ABOUT 5½ BY 4 INCHES.

Form No. 4 is a reduced copy of the daily time slips, which are used by both day workers and piece workers, though those for the day workers are on white and those for the piece workers on buff-tinted paper. These forms are padded by the printer in pads of fifty each, so as to be convenient for use in the departments. A workman on commencing a job is handed one of these time slips by his department clerk. The latter, as he handles the shop orders, has ready access to all the information necessary in the making out of these slips. On completion of the job, this slip is handed back by the workman to the clerk, who fills in the number of hours, and gives the man a slip for the next job on which he is going to work. The clerk O. K.'s all these slips, and turns them into the accounting department at night or early next morning. The slips for such jobs as are unfinished at night are also turned in, and new ones issued to the men in the morning. These slips are then priced and extended by the cost clerks, the amounts on the day-worker's slips being summarized and charged to the different cost sheets representing the shop orders on which they apply.

On the time slips made out for the few men who do work for which no formal written shop orders have been issued, is recorded briefly the nature of such work. "Standing order numbers" are no longer used, having been considered undesirable and abolished.

Piece workers on commencing jobs are also handed piece-work vouchers (see Form No. 5) by the department clerks, which are issued in duplicate. These are retained by the workmen until the work is finished, which may be several hours or several days, when after being O. K.'d by the inspector and the foreman, they are turned into the accounting department. Here, after being summarized in a memorandum book, the amounts are credited to the workman on the weekly pay roll. After this they are passed to the cost clerks to be charged up on the cost sheets, when any difference in or duplication of quantities should be at once detected. The duplicates, which are also O. K.'d by the inspector and the foreman, are held by the workmen and surrendered to the paymaster on being paid, so as to avoid disputes.

Piece-work vouchers are on pale blue paper. They are the same size as daily time slips, so that both can be conveniently brought together in bunches when compiling detailed labor costs, etc.

From the daily time slips a complete analysis of the weekly pay roll for use in the general books can be quickly obtained, all time charged to shop-order numbers being a direct charge to "Manufac-

turing" account, and the balance (which is comparatively small) being charged to such expense accounts as "Cost of Power," "Store-House Expense," "Department No. 1 Expense," "Department No. 2 Expense," etc. This is rendered more easy by having separate pay rolls for each department. At the foot of each pay roll its analysis is recorded. The agreement of such an analysis with the amount of the pay roll is a splendid check on the latter as to the accuracy of the number of hours recorded, and the rates, extensions, and footings.

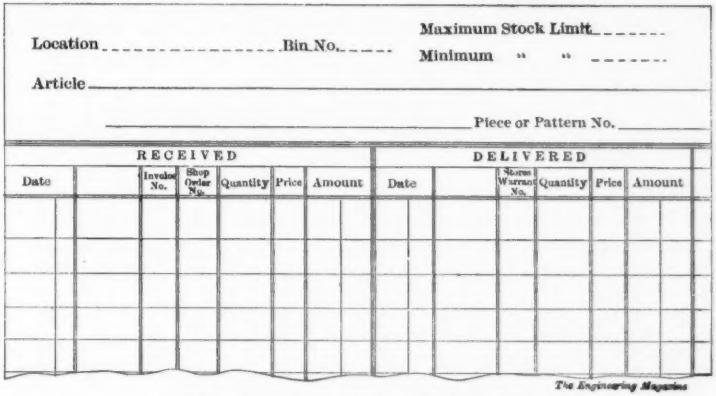
All time of mechanical engineers and draftsmen is charged as far as possible into the different cost sheets, detailed time reports being turned in from the drafting rooms. This is very important in obtaining actual costs, especially in the case of work done on "Personal" shop orders, of which such time often constitutes a considerable item.

On the daily time slips will be noticed places for the recording of machine tolls. Rates of toll per hour have been established for the use of each of the machine tools in this works. The method by which these rates have been arrived at will be described a little later. The time during which the different machine tools are in use is filled in on these time slips by the department clerks, and is figured out just like the time of the workmen. From the time slips these amounts are also summarized and charged to the cost sheets. A summary is made at the end of each month of the total amount of these tolls so charged up in each productive department, forming the basis of an entry in the general journal which is debited to manufacturing and credited to the expense of the various productive departments.

All goods are purchased by the purchasing agent, who issues formal purchase orders bearing consecutive numbers. Purchase invoices go in the first place to the purchasing agent, who checks quantities from the receiving clerk's daily record of receipts book, prices and terms from the copy for the purchase order, and then marks off the latter. The invoices are here consecutively numbered, and passed on to the accounting department, where, after the extensions and footings are checked, they are entered up in the purchase journal.

In the case of goods purchased for stock, these invoices are as contra through the purchase journal debited to "Stores" account in the general ledger. They are then passed on to the store keeper, who debits in detail the various stores accounts in the stores ledger (see Form No. 8), notes on the invoice the stores-ledger folio, and returns the invoice to the accounting department to be filed away. In the case of goods purchased for use on specific shop orders or outside jobs, which do not go to the store house at all, the contra through

the purchase journal is a debit to manufacturing account. These invoices are then passed on to the cost clerk, who debits in detail the various accounts in the cost ledger (see Form No. 9), and notes that he has done so on the invoices, after which these are filed away.


Location _____ Bin No. _____ Maximum Stock Limit _____
Minimum " " _____
Article _____
Piece or Pattern No. _____

RECEIVED							DELIVERED						
Date		Invoice No.	Shop Order No.	Quantity	Price	Amount	Date		Stores Warrant No.	Quantity	Price	Amount	

The Engineering Magazine

FORM 8. STORES LEDGER. REDUCED SIZE.

Nearly all goods are purchased either for stock or for use on some specific shop order or outside job. The exceptions are such as fuel and sundry supplies used in the power house which are charged to "Cost of Power," fodder charged to "Stable Expense," and sundry articles of the nature of process supplies used exclusively in certain other departments, which are charged to their expense accounts, etc.

Form No. 8 is a reduced illustration of the stores-ledger sheets which are bound in loose-leaf form, there being two inches of blank margin at the extreme left of each for binding purposes. At the top of the account is given the name or description of the article, with its piece or pattern number if it has one, the location and bin number, and maximum and minimum stores limits. Though not practicable in every case, both maximum and minimum stores limits are used as much as possible, the fixing or ignoring of these being left chiefly to the judgment of the store keeper.

In addition to debits to stores-ledger accounts being made from purchase invoices in the manner already described, they are also made from closed stock shop orders and from stores debit notes (see Form No. 7). On completion of a stock shop order, the quantity of articles delivered to the store house by the last department working on it is noted on the back of the order, and signed for by the store keeper

COST SHEET FOR SHOP ORDER NO._____

Description _____

Date	PARTICULARS	Direct Material	Direct Sundries	Direct Labor	Machine Tools	Indirect Expense Percentage	Total Debits	Total Credits

The Engineering Magazine

FORM 9. COST SHEET. REDUCED SIZE.

or one of his assistants who receives them into the store. This quantity is debited to the account in the stores ledger, the price being afterwards obtained from the closed cost sheet made up by the cost clerk.

Stores debit notes are made out by department foremen whenever they return into store any surplus or scrap material left over from a shop order. These are consecutively numbered as received in the store house, priced, extended, debited in the stores ledgers, and then turned in to the accounting department. Here, after being credited in detail to the cost sheets, they are summarized at the end of each month, forming the basis of an entry in the general journal debiting Stores account and crediting Manufacturing account.

The store keeper delivers nothing out of the store house except in execution of stores warrants (see Form No. 6), which must be signed by the head of a department or other authorized person. These must state the shipping or shop-order number for which the goods are required, or for what other purpose, if they are not to be used on some specific shipping or shop order. As these stores warrants are executed, they are consecutively numbered by the store keeper, priced, extended, and quantities and amounts credited to the respective accounts in the stores ledgers. They are then passed on to the accounting department, to be charged up in detail in the cost ledgers, and then summarized at the end of the month, forming an entry in the general books debiting Manufacturing and other accounts and crediting Stores accounts.

Most stores warrants are executed on the same day as presented at the store house, though some have necessarily to wait a while,

for obvious reasons. In such cases temporary notations of the quantities are made in pencil on the credit or delivered side of the account in the stores ledger, some distance below the last entry. When the goods are actually delivered, these pencil notations are obliterated and credited above in ink. Similar pencil notations are also made on the debit or receipts side of an account when goods are ordered, the purchase or shop order number and quantity being stated. When the goods are actually received these pencil notations are obliterated and debited above in ink.

The foregoing simple method of keeping track of the quantities of different articles wanted and on order has been found to work admirably. Being in loose-leaf form, these stores ledgers can be divided up into any convenient sections. A separate book is used for lumber, another for brass and copper, another for complete machines, etc. In some cases the rough castings and finished parts of certain machines are kept together in the same book.

While, as far as possible, all stores are centralized and kept in the store house, there are some which must necessarily, for the sake of convenience, be kept in the various departments. These are known as "Department Stores." As few as possible of such are kept. Their accounts are kept in the stores ledgers. As an example, the lumber and supplies used in the pattern shop are kept in that department. The department clerk, however, looks after them, and turns into the store house each day stores warrants for whatever have been used. Similar conditions exist in the carpenter's shop. In the blacksmith's shop certain kinds of iron must be kept. There are a few more of such cases in other departments. Said "Department Stores" are, however, surveyed periodically by the store keeper, any slight shortages being charged to the expense accounts of the departments.

The cost sheet used in the cost ledgers is illustrated by Form No. 9, which is in reduced size. These are in loose-leaf form, with two inches of blank margin at the left for binding purposes. Separate ledgers are reserved for the cost sheets of each of the three different classes of shop orders, viz, "Personal," "Stock," and "Plant" shop orders. At the top of each cost sheet is stated the shop-order number which it represents and a general description of the work. They are ruled in tabular form. The debits are written in black ink, and the credits in red ink.

In the "Direct Material" column is charged material from purchase invoices and also from stores warrants. In the "Direct Sundries" column are charged direct sundry charges other than material,

which may come from the purchase invoices, petty-cash vouchers, etc. In the "Direct Labor" column is charged direct labor from daily time slips and piece-work vouchers. In the "Machine Tolls" column are charged machine tolls from the daily time slips. The indirect manufacturing expenses (other than such portion as is embodied in the machine rates themselves) are charged as a percentage on the amount of direct labor and machine tolls combined. These percentages are added when a cost account is closed, and also to such cost accounts as are open at the end of each month. They are listed monthly under the various productive departments by the cost clerk, forming the basis of an entry in the general journal, which is debited to Manufacturing account and credited to the expense accounts of the various productive departments.

In fixing these percentages, each of the nine productive departments is treated separately and has a different rate of percentage. The other manufacturing expense account being at the end of each month closed out and distributed into the expense accounts of the productive departments, these departmental expense percentages are in this way made to cover the whole of the indirect expenses of the factory. The manner in which this is done will be explained later.

After being closed, the cost sheets are taken out of the cost ledgers and filed away in transfer cases. They are summarized and dealt with in the general books as follows:—

The costs of Personal orders are entered in the cost column headed "Manufacturing Account" at extreme left of sales journal (see Form No. 10). The costs of Stock orders closed during each month are summarized and form a debit to Stores account and credit to Manufacturing account, which is made by an entry in the general journal on the last day in the month. The costs of closed Plant orders are likewise summarized and journalized, forming debits to Plant accounts, Plant Repair or other expense accounts, and a credit to Manufacturing account.

The items charged in the first three columns of a cost sheet, viz, "Direct Material," "Direct Sundries" and "Direct Labor," constitute the "Prime Cost," which is also often spoken of as the "Direct" or "Flat" cost. When the machine tolls and the percentages to cover the other indirect manufacturing expenses have been added, the "Cost of Production" is obtained. This latter cost thus includes every expense, direct and indirect, till the goods are delivered at the factory door (or in the case of outside jobs, till the work has been completely erected and tested). It does not include the cost of selling, nor of

Cost Prices to be Entered Below		DR SALES JOURNAL FOR MONTH OF ..... 190 ..... CR.												
Dr. Trading A/c		Date	Ship's Order No.	Invoice No.	Customer	Sales Led. Fo.	Amount	Trading A/c	Freight Outward		Other Genl. Ledger A/cs		
Cr. Stores	Cr. Manuf'g										Name of A/c	Led. Fo.	Amount

The Engineering Magazine

FORM IO. SALES JOURNAL. REDUCED SIZE.

general office, administrative, and financial expenses. These latter are considered by the sales department, in fixing selling prices, as an additional percentage on the "Cost of Production" price of each article, thus bringing a figure, the difference between which and the selling price is net profit. This latter percentage is changed from time to time according to the amount of sales, and is very elastic, a large increase in the sales permitting of a considerable reduction in the percentage to be considered.

Referring to the two cost columns at the left of the sales journal, one headed "Stores" account and the other headed "Manufacturing" account (just mentioned), into which are entered the costs of all goods billed to customers—the footings of these are at the end of each month posted to the general ledger as a debit to Trading account and credit to Stores account and Manufacturing account. The costs entered in the Stores-account column are of such goods as are drawn out of store on stores warrants by the shipping clerk.

A separate cost ledger is kept for outside jobs. Most goods shipped to these are either drawn from the store house, or shipped direct by the merchants or manufacturers from whom they are purchased. Everything sent from the factory is shipped on consecutively numbered shipping orders, which emanate from the office of the superintendent of outside construction. The same form of shipping order is used as for goods shipped to customers, though a different series of numbers has been allotted. Of course, some goods have to be made and work done specially in the factory for specific

outside jobs. In such cases shop orders are issued bearing the shipping-order number.

The depreciation of plant and equipment is pro-rated monthly in the general books. On the last day of each month a journal entry is made debiting the monthly amounts of depreciation to the different departmental and other expense accounts to which they belong, the contra being a credit to "Reserve for Depreciation" account.

Other expenses, such as water rates, factory taxes, insurance, etc., are pro-rated in a similar way at the end of each month, the amounts being debited to the departmental and other expense accounts, and credited to "Accrued Water Rates," "Accrued Factory Taxes," and "Accrued Insurance," etc. Against these accrued accounts actual debits for such charges are made from time to time.

In the general ledger is kept an account called "Cost of Power." To this are debited the wages of the engineer and fireman who attend to the power plant, and of the millwright and oilers who attend to the equipment for transmission of power throughout the works; also all other expenses connected with the generation and distribution of power, such as fuel, oil, and sundry supplies consumed, maintenance, depreciation, and insurance of this plant and equipment, etc. At the end of each month a report is made by one of the mechanical engineers to the accounting department of the net amount of power estimated to have been consumed in each of the productive departments. This, computed on the basis of 1¾ cents per horse-power hour (which past experience shows to be approximately the cost of generating and transmitting power in this works) gives the data for a general journal entry debiting the expense accounts of the productive departments, and crediting "Cost of Power" account. So nearly accurate does this work out, that at the end of each month the debit or credit balance of the later account is invariably trivial.

The matter of machine rates, which has been briefly referred to in the foregoing, will now be more fully described.

Throughout the works there are about five hundred machine tools, each bearing a different number, and for the use of which separate rates of toll per hour have been established. The four factors entering into the composition of these rates are:—power consumed by the machine, maintenance of the machine, depreciation of the machine, and department expense (equivalent to interest on the amount of capital invested in the machine). The following is an illustration of the way in which they are computed. Take for instance a planer valued at $4,000.00, consuming on an average while engaged on the medium

class of work for which it is used, 9 horse-power per hour, and assuming it to be in operation 10 hours per day for 300 days in the year:—

interest on the amount of capital invested in the		
5 per cent. per annum repairs on $4,000.00	=	200.00
6 per cent. per annum depreciation on $4,000.00	=	240.00
An amount of indirect departmental expense, equivalent to		
27,000 horse-power hours at 1¾ cents per hour	=	$472.50
machine (*i.e.*, 6 per cent. per annum on $4,000.00)	=	240.00
Making a total for the year of		$1,152.50

$1,152.50 divided by 3,000 hours brings what is practically 38½ cents per hour as the rate of toll.

These tolls are charged into the cost accounts from the workmen's daily time slips, as already explained. In the case of a few machines which are only used periodically, and then for so short a time as to render the recording of it impracticable (such as cranes, grindstones, shears, etc.), their machine tolls are ignored altogether.

In the cost accounts of many factories the conditions are not such as to render machine rates necessary, the incidence between the different departmental expense accounts alone and the departmental pay rolls forming the basis of distribution. This is all right in connection with a department in which the machines are all of one kind and size; but in an engineering works these conditions do not usually prevail to any great extent, large machines and small machines working side by side in many departments together with mechanics working by hand alone. In such cases, the percentages figured as the ratios which the departmental expense accounts for a given period bear to the departmental pay rolls must be very misleading.

In the general ledger an expense account is kept with each of the nine productive departments. These are known as "Department No. 1 Expense Account," "Department No. 2 Expense Account," and so on. To each of these is charged all the overhead or indirect burden of the department, consisting of wages of foreman, assistant foreman, department clerks, general laborers, and any other time which cannot be allocated to any specific shop order. Also all sundry process supplies and other articles which cannot be directly allocated, such as oil, waste, emery wheels, sand paper, fuel, etc.; cost of power consumed, depreciation of machinery and tools and current repairs to same, and any other indirect charges incurred in operation.

In addition to the expense account of these productive departments, there are the other manufacturing expense accounts, common

to some extent to the whole factory, such as wages of superintendent and his assistant, clerks, gate keepers, watchmen, etc., store-house expenses, yard expense, general pattern expense, general tool expense, repairs to building, depreciation of building, etc. These are distributed monthly into the expense accounts of the productive departments, though necessarily somewhat arbitrarily, yet in what seems to be the most equitable manner, in view of the way in which they will ultimately be charged into the cost accounts. For instance, the wages of the superintendent and his assistants are divided up in proportion to the number of hands in each of the departments; repairs and depreciation of buildings to some extent in proportion to the amount of floor space occupied by each department; general pattern expense into the expense accounts only of such departments as work on castings; general tool expense in proportion to the amount of general tools used by each department, and so on. By treating this latter group of accounts in this way, a single rate of percentage has been obtained for each of the productive departments, covering not only the indirect expenses of the department itself, but also the other general expense of manufacture. This considerably simplifies matters, especially in connection with the cost-clerk's work, several additional percentages being avoided.

As there are nine productive departments, there are nine different rates of percentages. Usually these are not changed more than once a year. The debit or credit balances of these accounts, as shown by the general-ledger trial balance at the end of each month, which are generally small, indicate whether these expenses are being distributed as fast as incurred or not. If the balance is on the debit side of the ledger, the rate of percentage in use would appear too low, and if on the credit side, too high. However, there may be special or extraordinary circumstances increasing some departmental expense accounts in some months which do not necessarily impel a change in the departmental percentage rate, such as a strike of workmen, a dull period in which many of the machine tools are idle, an unusually heavy amount of repairs, etc. Said expense accounts are an index to these and other similar conditions, and are carefully analyzed by the accounting department every month. The question of departmental repairs is considered somewhat on a percentage basis, and so viewed, as shown in the fixing of machine rates; for to be guided altogether by the cost of actual repairs would be misleading, there being practically no repairs in some departments for several months, after which they become periodically heavy.

There is an extra percentage added to the cost sheets of outside jobs to cover the indirect outside expense, such as the salary of the superintendent of construction and his assistant, and the uncharged time and expenses of such of the outside men as are occasionally idle, etc. This is a percentage on the amount of direct outside labor.

Years ago, owing to ideas of false economy and other causes, chaotic conditions prevailed in this works. There was very little system at all. No records were kept of stores on hand, the store keeper trusting chiefly to his memory and observation. Consequently great quantities of valuable stores were overlooked and kept till they became obsolete, others being purchased or made as required. Workmen helped themselves to a great extent to anything they required, there being no stores warrants or similar documents. Foremen made whatever they considered necessary, and in just such quantities as they fancied, written shop orders being seldom issued, and even then to a great extent ignored. When standard machines had to be built, there would be excessive quantities of some parts on hand and none at all of others, thus causing great delay and expense. No time slips were used, and there was little attempt made at cost keeping, the prime cost being occasionally taken, and an amount added to cover the indirect manufacturing expenses, sometimes on the rate-per-hour and sometimes on the percentage-on-wages plan; but this partook more of the nature of an estimate or guess than of an actual cost. The piece workers were paid whatever their foremen reported was due to them, without further verification. The annual inventory was a perfunctory affair, the value in many cases having to be guessed at, making the revenue account and balance sheet very unreliable.

Now all this has been changed. Great economy is effected by having nothing made except in execution of written shop orders. Confusion and errors have been reduced to a minimum. The system of keeping track of and following up shop orders in progress by means of the card frames in the superintendent's office tends greatly to expedite delivery. The store keeper can immediately tell from the stores ledger just what is on hand and the actual cost of it. Any variations in the cost of articles from time to time, being clearly shown up here, can be quickly investigated. Actual costs of everything made are promptly obtained, the value of which information cannot be over-appreciated, especially in the case of job or personal worth wherein the selling price is often governed altogether by the cost. Moreover, the cost sheets being in analytical form, the causes of variations in costs are readily observed. The cost clerks can also

quickly compile detailed labor costs, and make comparisons between prices paid at day-work rates and piece-work rates, facilitating the creation and revision of the latter.

In the sales journal, the actual cost of everything billed being shown on the same line as the amount charged to the customer, the profit on each invoice is at once apparent, and any loss quickly investigated.

A pro-forma revenue account and balance sheet is made up at the end of each month from the general-ledger trial balance without taking inventory, the accuracy and completeness of the cost system and the way in which it is perfectly controlled by the general ledger rendering this possible. The assets shown to the debit of Stores account and Manufacturing account, the former representing the value of the stores on hand, and the latter the value of work in progress, both in the factory and outside, are verified by their agreement with the aggregate of the debit balances taken from the stores ledgers and the cost ledgers, which these two general ledgers accounts respectively control.

An actual inventory is taken at the end of each fiscal year by closing down the works for two days only. So accurate, however, are the cost accounts and the stores accounts, that this annual inventory might almost be dispensed with altogether, the quantities on hand as per the stores-ledger accounts being checked from time to time with actual counts made of the articles themselves.

The expense of operating this system, while considerable, is well offset by the benefits obtained. There are in the neighborhood of ten-thousand separate accounts in the stores ledgers, most of which are active; these are kept up by four clerks, receiving on an average not more than $1.50 per day each, who also do all other clerical work in the store-keeper's office. Considering that there are at times upwards of $500,000 worth of stores on hand, it is well worth such an expenditure for clerical help if only to keep track of the quantities. The cost ledgers are kept up with even a less expenditure for clerical help than the stores ledgers.

With necessary changes and modifications, this system can be adapted to suit the requirements of most engineering works, and where the business is too small to warrant the expense of a complete system, or other conditions render it impracticable, parts of it may be advantageously installed. With further changes to suit special conditions, it can also be used in many other factories.

TRAVELING CANTILEVER AND LOCOMOTIVE CRANES, NEWPORT NEWS SHIPBUILDING & DRYDOCK CO.

SHIPYARD CRANES AND THEIR FUNCTIONS IN MARINE CONSTRUCTION.

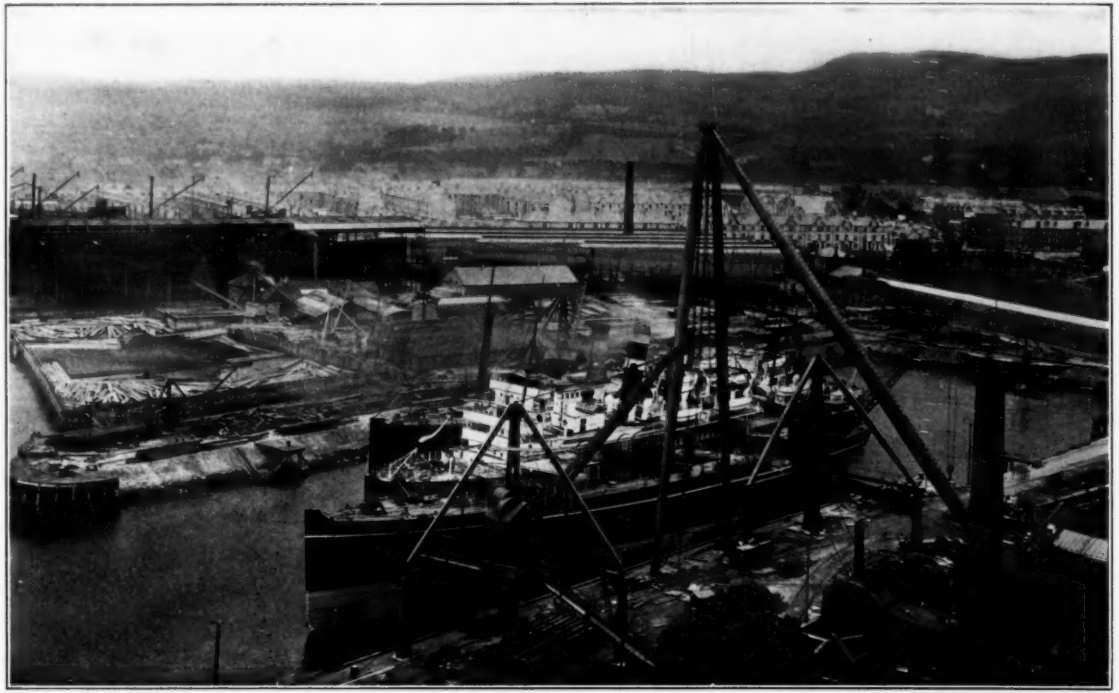
By Jos. S. Shultz, U. S. N.

Lieutenant Shultz's discussion does not exclude the mechanical features of the installations he describes, but makes most prominent the broader effect they have on the economy of ship-building. While his review is addressed primarily to American practice, some of the most important and modern examples of British machinery in the same class are presented for comparison in the illustrations.—THE EDITORS.

IF, as so many people assert, it is still true that American shipyards cannot compete with others in point of cost in the building of modern maritime craft, this condition is not due to the methods of operation nor the machinery equipment now employed in the large yards on the Atlantic, the Great Lakes and the Pacific.

That such superior machinery is now available for the building of American ships is not, however, the results of a demand caused by a decided increase in domestic ship construction; but rather has the marked attention devoted recently to this industry been directly brought about by a realization that in this field could be successfully applied the methods and the devices perfected in the development of those industries so characteristically American, i. e., the manufacture of steel into structural shapes and the handling and transportation of ores and fuel.

It has been but a few years since every large steamship plying between America and foreign ports, when disabled or in need of repairs, would be put out of commission and towed back to the yard



SHEAR LEGS AND CRANES, SHIPYARDS OF WILLIAM DENNY & BROTHERS, DUMBARTON.

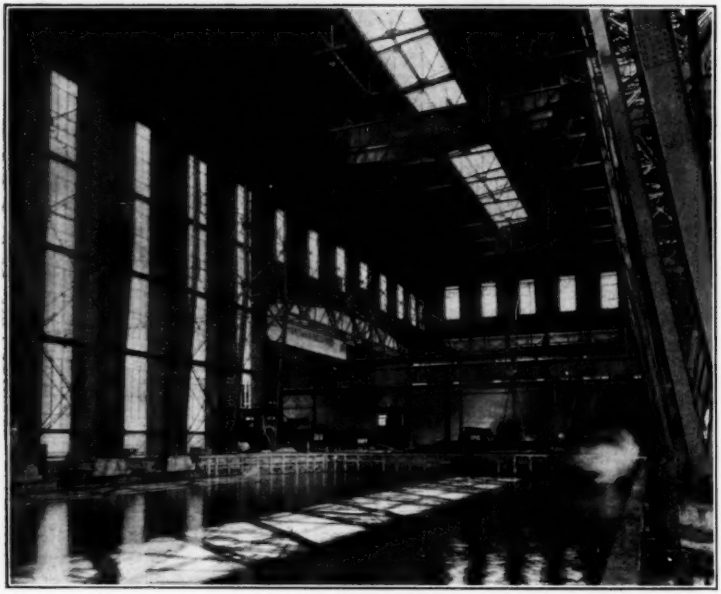
The shear legs in the middle are of 110-tons capacity; the cranes on each side (supported on pillars so as to span high and broad ships) are 20-tons. The three vessels lying in the dock are all turbines—outside, the "Loongana," Union Steamship Co. of New Zealand; middle, the Midland Railway's cross-channel steamer "Londonderry"; nearest, the British Steam Navigation Co.'s "Lhasa."

where it had been built for whatever work was necessary; and even at late as July of last year the giant Cunard freighter "Slavonia" was placed in a naval drydock at New York simply because there was no commercial shipyard in the United States where the hull could be cleaned and painted without a delay of an indefinite length of time. The fact is that, as the result of years of experience, the building of wooden ships had advanced to such a degree of perfection in America that vessels of that class constructed in home yards were without a peer in point of both cost and general merit; but when the change from wood to steel hulls was made there were other and more absorbing lines of industry to which the American workmen and capitalists were directing their attention—the result being that ship construction was held in abeyance until, in the advancement of the former, means were developed which it was seen could be very advantageously employed in the building and repairing of steel ships.

A shipyard which is designed for both repair and construction work (and every successful one must be, in order to keep in continuous and economical operation during intervals when no new craft are being built, or *vice versa*), should have more or less completely equipped the following departments:—First, repair and manufacturing shops, where all of the material necessary for the vessel and its machinery is made and put together. Second, storehouses for supplies and equipage, where the raw materials, spare parts, and other ships' requisites are held ready for immediate issue. Third, wharves, quay walls, and building ways, where berthing space for craft under repair and facilities for initial construction are provided. And fourth, drydocks (floating or graving), where opportunity is afforded for ready access to the hull and submerged mechanical parts. But expeditious and economical work in connection with every one of the above can be carried on only with a complete and modern installation of cranes; and therefore this fifth division, though by no means the most important, is at least the essential link which connects the otherwise isolated portions and binds them into an interdependent, smooth-working, composite plant.

In those early American yards from which so many staunch merchantmen were launched, and in the present ones where sailing craft are exclusively built, a jib was rigged to the mast of one of the vessels or to a fixed strut on shore, and this furnished all of the required means for transfering and handling material. And even in many of our present modern plants may be found a stationary wharf crane of the jib type, unloading coal or pig-iron from a barge, or a revolving pillar crane handling the moulds of a foundry—but these are

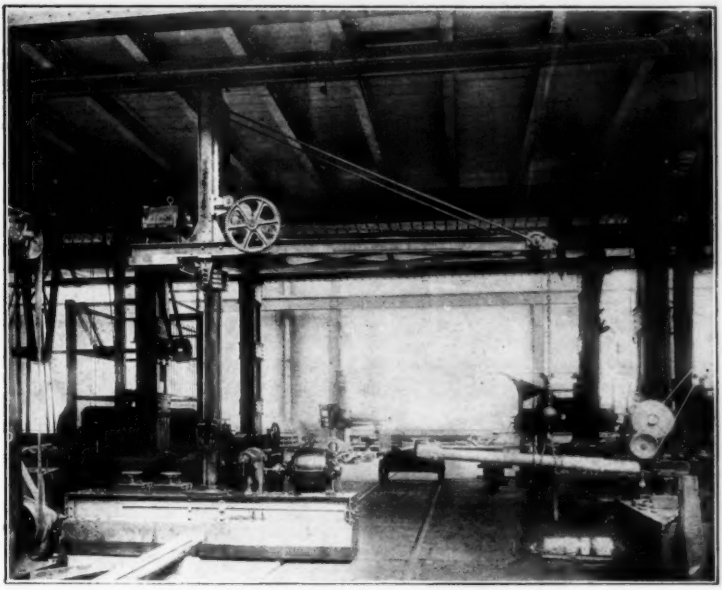
the relics of the initial equipment, which soon proved wholly inadequate for the work demanded of a transportation agent in any plant bidding for the care and construction of modern steam- and war-ships.



ONE-HUNDRED-TON TRAVELING CRANE OVER THE WET DOCK, NEW YORK SHIPBUILDING CO., CAMDEN, N. J.
Built by William Sellers Co., Phila., Pa.

The designer of the crane machinery of a modern ship-building yard containing the above noted departments has a most varied assortment of conditions to meet; but fortunately his otherwise arduous task is greatly lightened by the fact that not all of his designs need be original to answer fully the requirements of the service to which they will be placed. In lieu of the clumsy pillar cranes which stood in the center of the iron and steel foundry, and from that position served but a very small part of the floor, there is substituted an electric bridge traveling crane with a movable trolley—an exact counterpart of the one used in the structural-steel mill—which covers every square foot of the floor area, takes up no valuable space, and is operated by one man, with a consumption of power only when actually in motion, thereby saving the continuous steam or hydraulic power needed for the pillar cranes, and the wages of the individual operators. In the brass foundry and the coppersmith shop, where the material is in pieces of comparatively light weight, 5- or 10-ton elec-

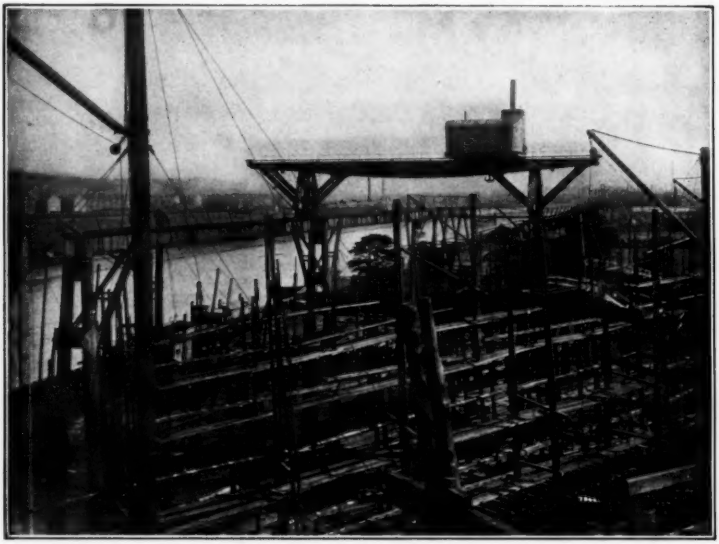
tric cranes of the bridge type, but operated by hand-ropes from the floor, tend towards a still further reduction in the expense of handling moulds and finished castings. And the manufacturer of the transportation equipment for the structural-steel plant furnishes directly from his stock the cranes necessary for the boiler and machine shop in the shipyard. A large traveling crane of this kind, with a capacity of 50 or 60 tons, is located on tracks only a short distance above the floor and moves with absolute precision and no loss of time the large steam cylinder or the assembled engine, the propellors or the immense driving shafts, the boilers or the condensing outfits; and above this, with half the span, fast-moving and similar but smaller cranes serve the individual lathes, drill-presses, etc. Thus



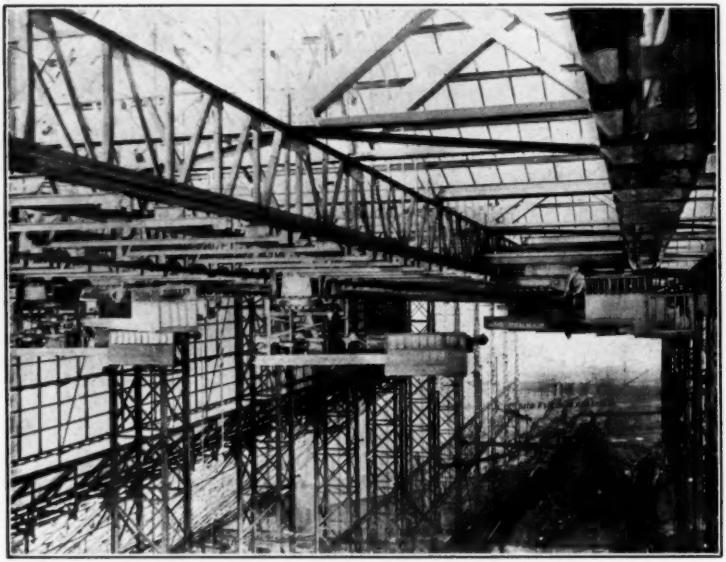
ELECTRIC SINGLE-RAIL TRAVELING JIB CRANE, 1½-TONS CAPACITY.

Radius 12½ ft., height to top of post 18½ ft.; travels on a rail flush with floor. Jessop & Appleby Bros., Ltd., Leicester and London.

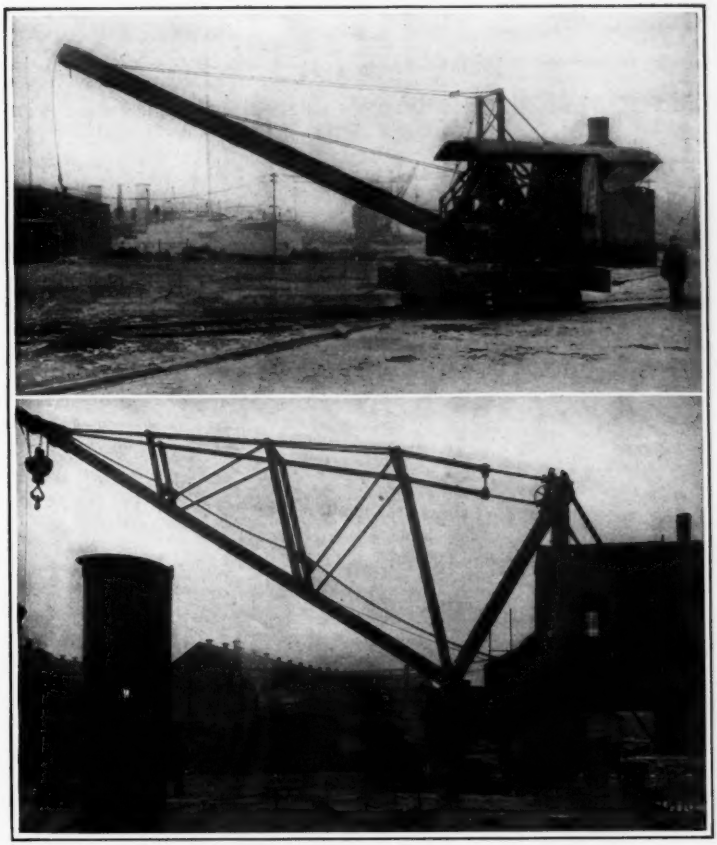
does the projector of a ship-building plant have for his immediate use, and at a cost far below that of a specially designed apparatus, the equipment which has been perfected and improved for the making of structural steel; and he uses these same cranes in his boat shops, for punching, shearing, and riveting the hull, deck, and bulkhead plates, and for forging the beams, angles, and channels in the



GANTRY CRANE LONG USED IN YARDS OF MESSRS. ALEX. STEPHENS & SONS, GOVAN. Erected 33 years ago, and only lately displaced. 60 ft. above keel blocks, 70 ft. span; lifting power 50 tons—ample in its day for the size of steamers then built. Replacement began about 15 years ago. By its use boilers, machinery, and sometimes even coal were shipped before launching.



CRANE EQUIPMENT, YARDS OF SWAN-HUNTER & WIGHAM-RICHARDSON, LTD. There are two berths, each equipped with five cranes.



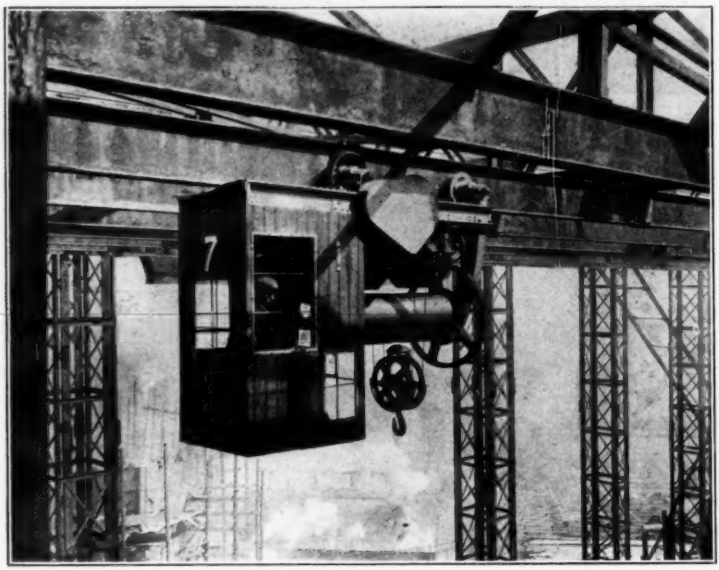
LOCOMOTIVE AND TRAVELING DOCK CRANES, NEW YORK NAVY YARD.

The upper figure shows a 15-ton locomotive crane; the lower one is a 40-ton traveling crane, revolving on the turntable supported on the double truck shown.
William Sellers Co., Phila.

frames; and in his storehouses, where he also has installed the hand hoists and telpherage systems employed in the rolling-mill and blast-furnace department of the steel plant. And outside, on standard-gauge railroad tracks, locomotive cranes—duplicates of those in the yards of structural mills—unload the material and transport it from point to point as required.

Here, however, the analogous use of cranes in the two industries ceases; for it was demonstrated when the keel of the first large steel vessel was laid in the United States that economical and rapid con-

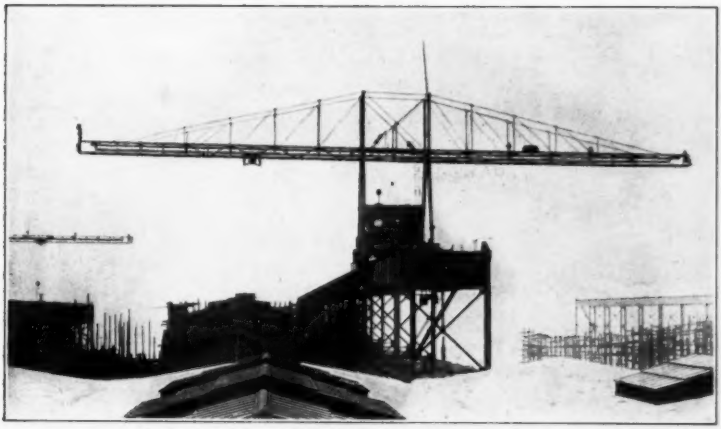
struction could be made only with the aid of a device which would serve every part of the vessel building, from bow to stern, and from port side to starboard. But this problem proved comparatively easy of solution, for with the ideas gotten from observation upon the tramways used in transporting ores and fuel, there was soon perfected the cantilever ship crane, which, when installed on a framework of sufficient height to clear the topmost part of the completed vessel and of a length corresponding to its over-all dimension, transfers and installs most efficiently every piece of material entering into the actual shell of the vessel. This type is usually built for a capacity of 5 tons



OVERHEAD TROLLEY HOIST, SHIPYARDS OF WM. DOXFORD & SONS, LTD., SUNDERLAND.
Lifts 3 tons at speed of 150 ft. per minute; travels 400 ft. per minute.

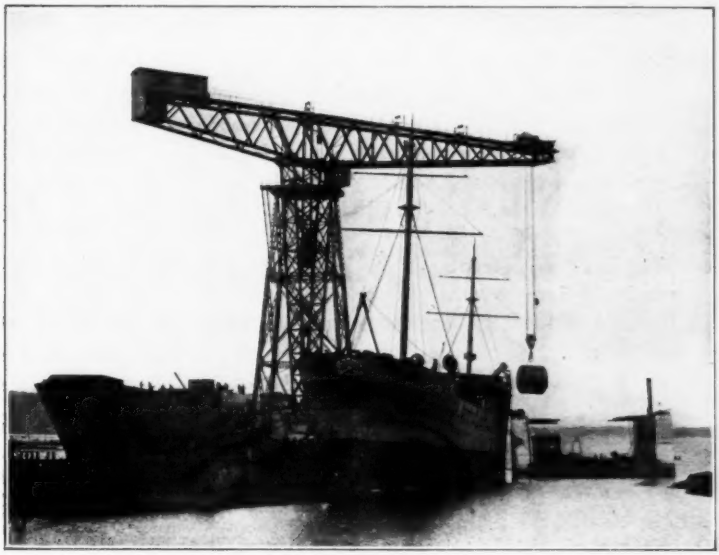
at the extreme end, and the longest one is 360 feet from one cantilever extremity to the other. The load is counterbalanced throughout its movement; the speed of vertical hoist varies from 350 to 700 feet per minute, of horizontal trolley travel from 400 to 800 feet, and the entire crane moves along the trestle at 400 to 700 feet per minute, depending upon the load and the wind pressure prevailing.

Only the stationary portions of the hull proper, however, are placed in position while the vessel is on the building ways—the engines, boilers, dynamos, and other machinery and the armor plate on war craft are put aboard after launching, when moored alongside the



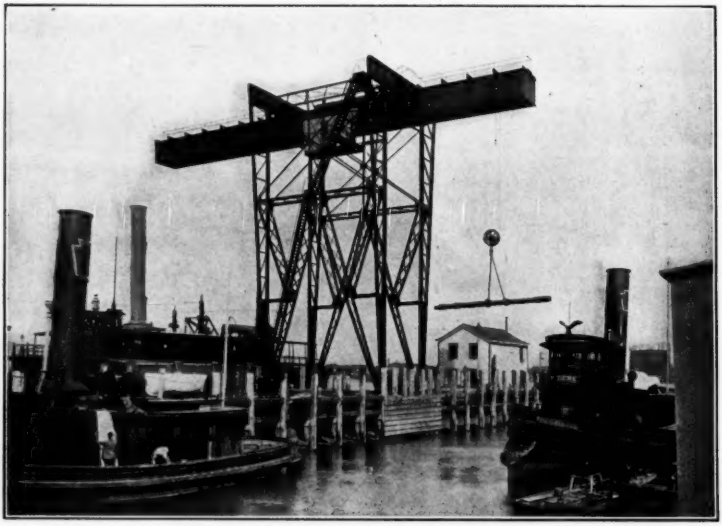
LARGE TRAVELING CANTILEVER CRANE ON ELEVATED RAILWAY, NEWPORT NEWS SHIPBUILDING & DRYDOCK CO.

Three partially completed vessels are on the building ways. Crane built by Brown Hoisting Machinery Co.



GIANT CRANE OF "HAMMER" TYPE, 150-TONS CAPACITY, ELECTRIC-DRIVEN.

Height 150 ft. Large radius 135 ft., small radius 78 ft.; lifts 150 tons at 3 1-3 ft. per minute at 60 ft., 50 tons at 125 ft.; slews 360 degrees in 10 minutes; weight 450 tons. Later type has crabs on both arms, acting mutually as counterweights. Benrath Engineering Co., Benrath and London. Supplied to Howaldt Works, Kiel, to William Beardmore & Co., Ltd., Vickers, Sons & Maxim, Ltd., etc.

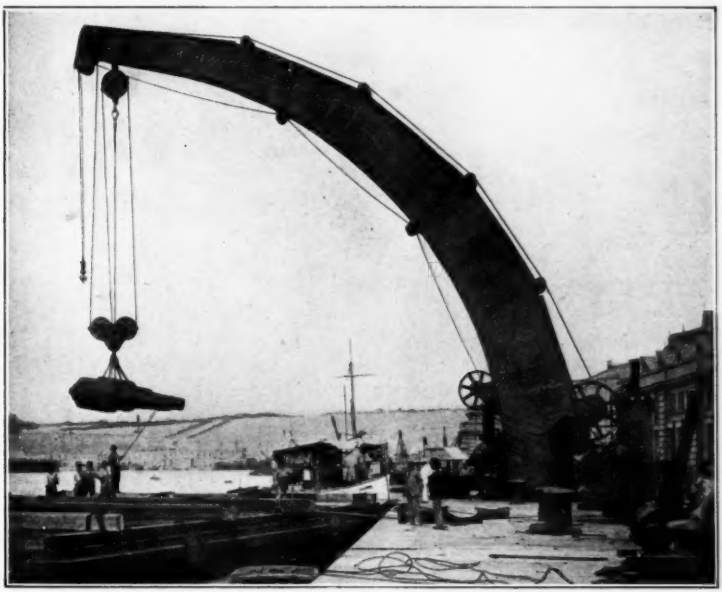


FORTY-TON FIXED GANTRY WHARF CRANE, PENNSYLVANIA RAILROAD, HOBOKEN, N. J.
Built by William Sellers Co., Phila.

wharf or while in drydock; and the repairs to all vessels are made only under these latter circumstances. Consequently there are two other classes of cranes which are requisite for the complete operation of the shipyard plant, and which are peculiar alone to maritime construction work. These are the ponderous dock cranes (traveling and stationary), and those of the floating class; and inasmuch as shipbuilding in America has but recently assumed its present businesslike proportions, there have been developed no general types for cranes in these classes. The resulting mechanisms are therefore wholly diverse in character, and are merely expositions for the ideas of the individual naval experts. All, however, are more or less intricate in design and make-up, and therefore the initial cost of this special machinery, useful as it is for only a very restricted field, would prohibit its manufacture were it not for the fact that the builders of the cranes, tramways, and conveying machinery for general use can apply their methods and employ their workmen on these new and unusual constructions to advantage and with practical commercial economy.

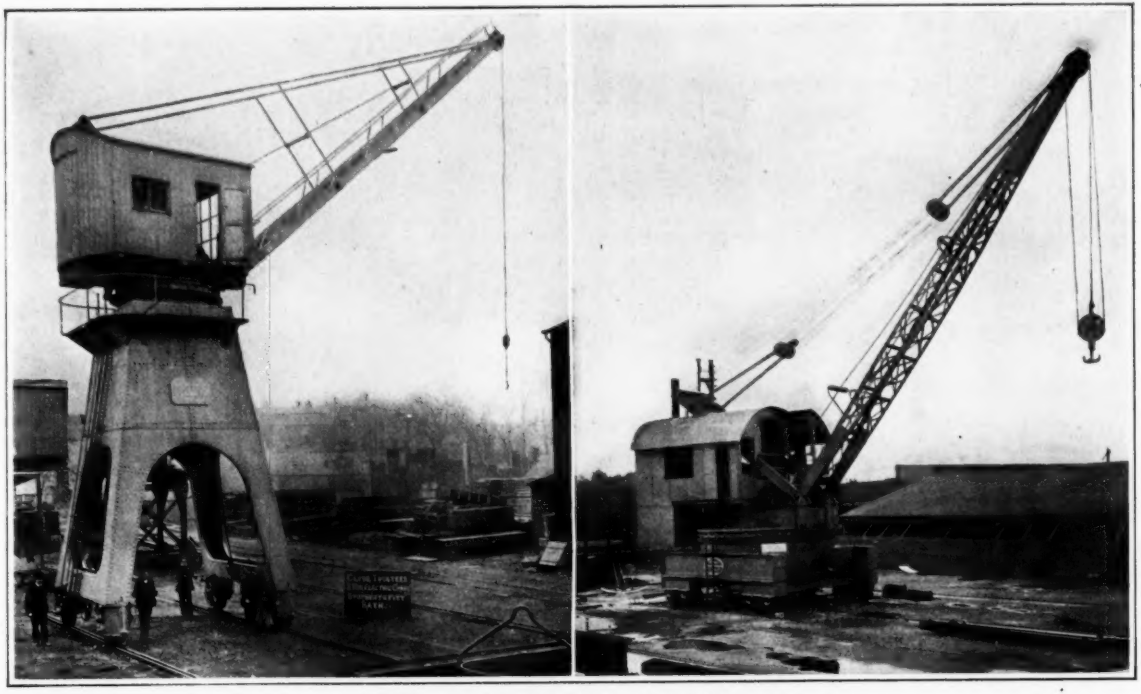
Dock cranes of the traveling type move on tracks built along the berthing wharves and around the drydocks, and all have a very wide gauge, which varies from 18 to 60 feet. One of the most useful of these structures is of the cantilever jib class, mounted upon a heavy, pivoted base, revolved through a complete circle by means of a train

of gears, one 8 inches in diameter and the other 20 feet. The framework supporting the revolving superstructure rests upon two separate trucks, each containing eight heavy cast-iron wheels; and, in order to facilitate movement around the short-radius curves at the head of the docks and in the angles of the wharves, the truck supports are also made movable. The jib is a cantilever, inclined at an angle of about 40 degrees to the horizontal, with a heavy A-frame lower chord connected to the top chord through a system of Warren truss bracing. The capacity of this crane is 40 tons, and the load is carried on a heavy chain supporting the large pulley block, the center of which is 80 feet from the center of the crane base, thus giving an opportunity for removing material from all parts of the largest vessel when in drydock. The load is balanced by placing the boilers and engines at the opposite side in an overhanging structure. There is also a small 10-ton auxiliary rapid-motion hoist at the extreme end of the jib for handling small loads more quickly than by the main racking device. The most interesing part of the mechanism, however, is the two large screw shafts, connected at the inner end



FIFTY-TON STEAM CRANE, FAIRBAIRN TYPE, GOVERNMENT DOCKYARD, MALTA.

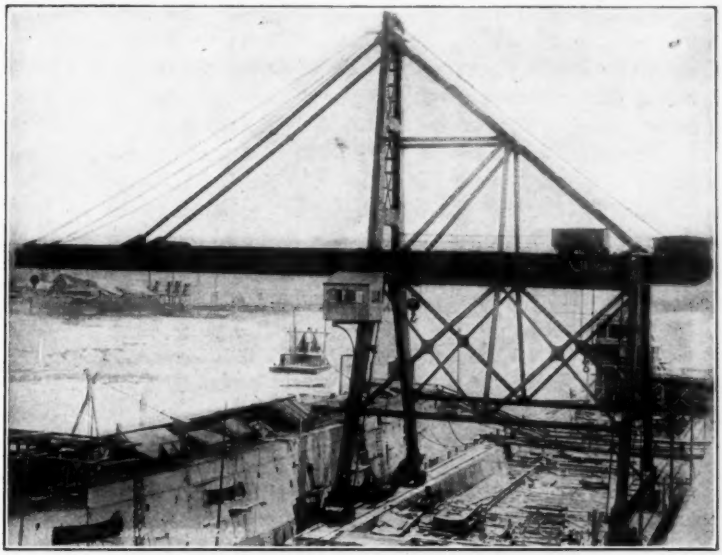
Height to center of jib top pulley 65 ft.; lifts 50 tons at 60-ft. radius; two pairs of engines, one for hoisting and one for slewing. Built by Cowans, Sheldon & Co., Carlisle.



PORTABLE CRANES FOR DOCK AND SHIPYARD USE.

On the left, a 3-ton electric dock-side crane, built by Stothert & Pitt, Ltd., Bath, for the Clyde Trustees. On the right- a 30-ton steam traveling crane, by Cowans, Sheldon & Co., Ltd., Carlisle, for construction work in H. M. dockyards.

to the top chord, by which the boom is raised and lowered through a distance of 8 feet with the absolute precision necessary when setting heavy engine parts or armor plate. This crane is used very extensively in government plants, and in point of utility for this phase of naval work is unsurpassed. It is shown on page 65.



FOLDING-JIB GANTRY DOCK CRANE, TRAVELING TYPE, FORE RIVER SHIP & ENGINE BUILDING CO.

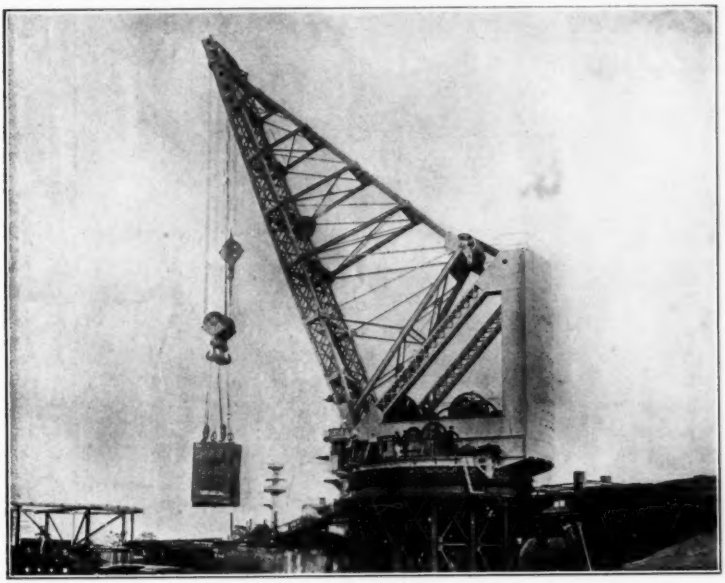
75 tons capacity. Built by Wellman-Seaver-Morgan Co.

Another extremely interesting crane of this class is one of 75 gross-tons capacity, shown above, constructed so as to combine the characteristics of the above dock cranes and also the peculiar features and advantages of those of the floating type. Essentially this consists of a massive A-frame on the dock side, 105 feet high, and a similar one, but lower, on the inshore side, which support the simple plate-girder beam for the shore travel of the trolleys, and the movable overhanging cantilever arm for the trolley runways when serving a vessel lying alongside the wharf. The four ends of these A-frames separately rest upon a truck containing four heavy double-flanged wheels—the two tracks (standard-gauge) upon which the wheels move being 56 feet center to center. The cantilever overhang, which may be also used as a jib for setting tall masts, is 94 feet long and when in a horizontal position forms, with the inshore portion, a

continuous runway for the hoisting trolleys over 160 feet in length; and, therefore, owing to the open construction of the supporting frames, material may be taken from cars on a railroad inside of the crane-track and conveyed thence directly to the position for which it was designed on board the vessel building. The two trolleys have a combined maximum capacity of 168,000 pounds; and the smaller one traversing a track on the inside flanges of the plate girders is designed to lift and transport a load of 56,000 pounds, the speeds being respectively 22 and 150 feet per minute, while the other, with a capacity of just double this, raises its load 11 feet per minute and carries it horizontally at twice this speed. The two, being capable of working simultaneously in connection with the same piece of material to be handled, and being independently controlled, are most efficient adjuncts for setting into position the heaviest and most delicate parts of the ship's equipment. The 10-ton lifting tackle at the extreme outboard end serves for handling small loads and for the jib tackle when the cantilever is in an inclined position. This crane is self-propelling, is electrically driven throughout, and forms unquestionably the most elaborate machine of its class in the world. It is used in the shipyards of the Fore River Company.

Of the stationary dock cranes, including as they do the various kinds of shear legs, which are merely simple hinged or fixed struts for the support of the lifting tackle, there are very many, and for the most part wholly diverse examples to be found in nearly every shipyard. These are the oldest of modern ship cranes in point of development, for they form the next step after the abandonment of the crude jib; and, though their usefulness is materially impaired by the fact that all articles to be handled and every vessel to be dismantled or equipped must be brought within the radius of their action, they may, on account of this very feature, be designed for much heavier loads than either the movable dock or the floating cranes. Some of this kind are very intricate and elaborate, and particular reference is made to a noteworthy example (page 73) which is now in use in the yards of the Newport News Shipbuilding and Dry Dock Company. This has a capacity of 175 tons, which weight, together with that of the heavy superstructure, is supported upon a massive circular base, built of structural-steel shapes and plates. The jib is moved vertically by means of a most unusual belted mechanism, clearly shown in the accompanying illustration, and revolves horizontally upon a continuous line of wheels securely fastened each to each, the power being applied through a train of gears, the final one of which engages a rack located on the crane base

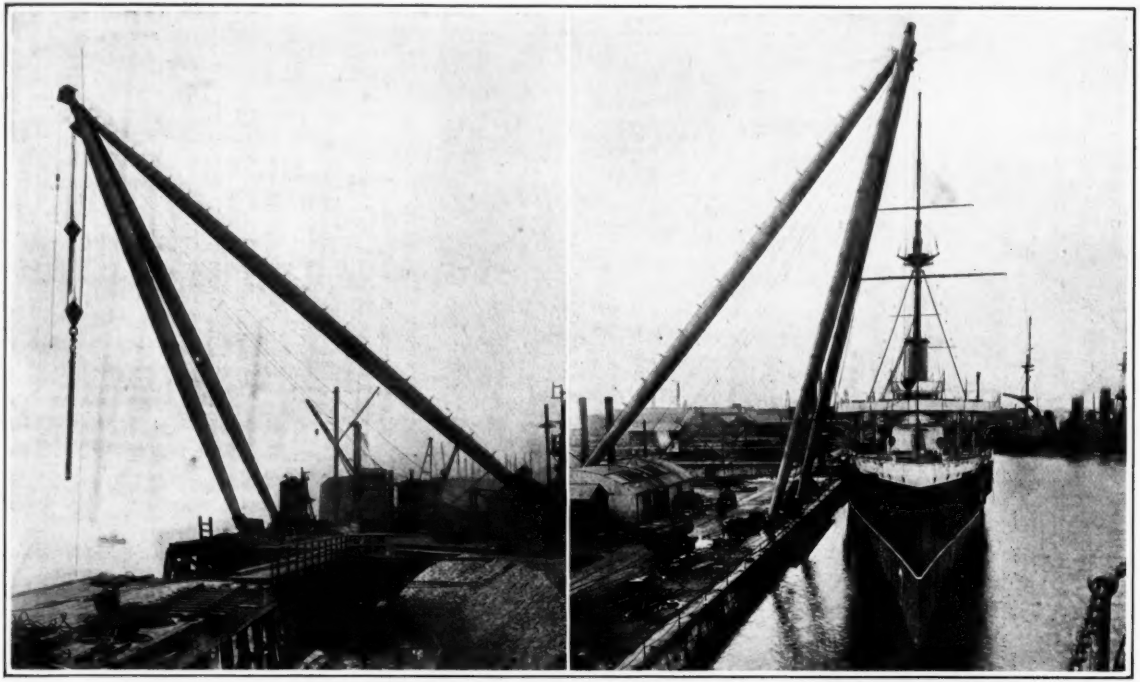
proper. The remainder of the transportation equipment employed by this company merits especial attention, for it is all of this highest class, and has contributed in no small measure to the unusual success of this typical and thoroughly American concern.



FIXED DOCK CRANE UNDER TEST, NEWPORT NEWS SHIPBUILDING CO.
The test load is of 300,500-lb. weight.

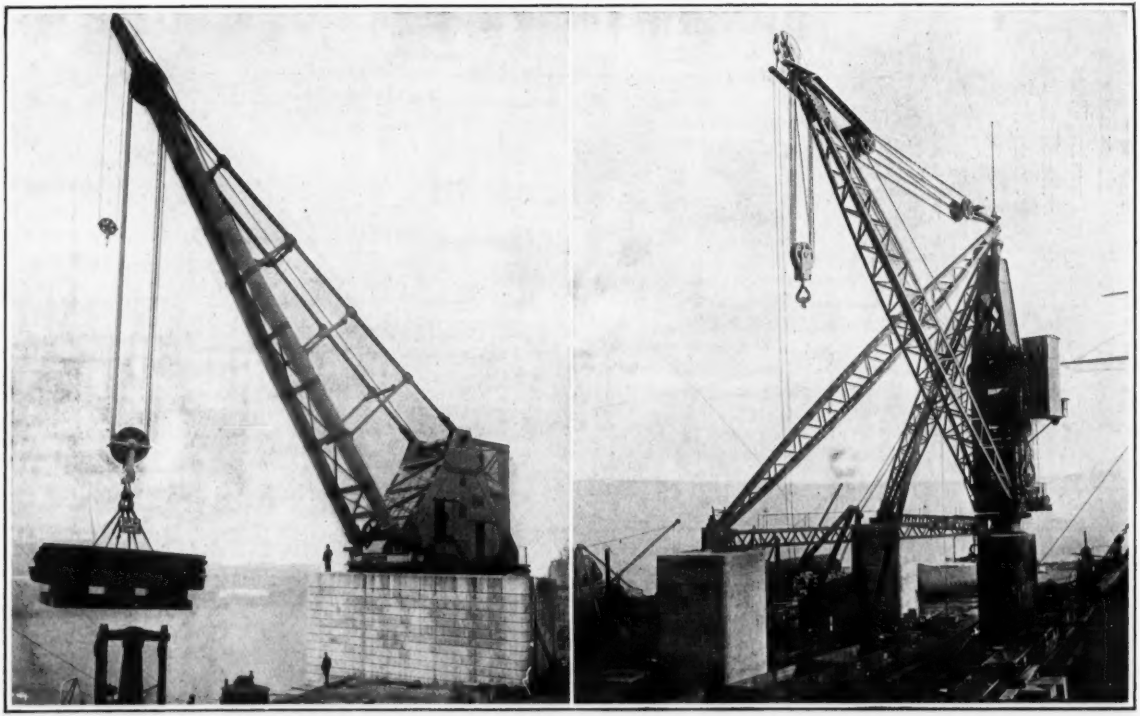
Floating cranes are perhaps the best examples of shipyard cranes proper, for they are the direct and ultimate result in the evolution of the simple jib attached to the mast of nearly every sailing vessel; but the modern structures of this kind are, too, the production of the manufacturer of the steel- and ore-handling appliances, and their development has been just as dependent upon these types as those others above described, ample proof of which is the fact that no improvements were made in them until this other transportation equipment had reached a very high state of perfection.

The most widely employed type of this class of machinery is that consisting of a heavy, rigid, vertical A-frame, from the top of which is led a tension member (usually capable of being shortened) supporting at its outer end the strong, swinging jib, securely fastened at the lower extremity to the pontoon between the legs of the A-frame. The hoisting mechanism is rigged to the end of this jib, and the



EXAMPLES OF LARGE SHEAR LEGS ERECTED IN BRITISH SHIPBUILDING YARDS.

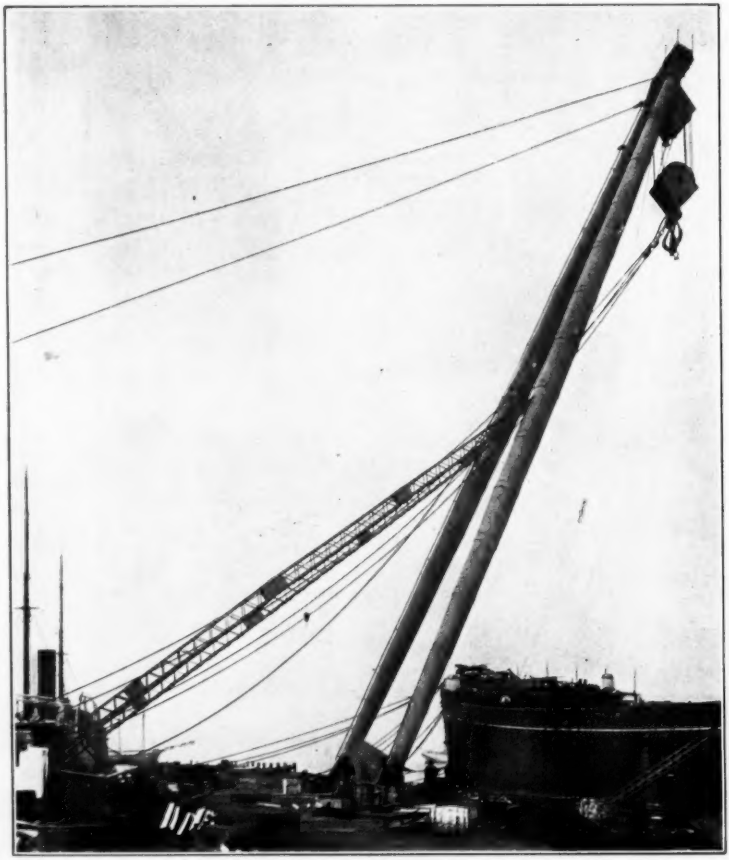
Those on the left, built by Hanna, Donald & Co. in 1902 in the yards of Palmer's Shipbuilding & Iron Co., Jarrow-on-Tyne, are of 120 tons working load; front legs 135 ft. long, 4 ft. 8 in. diam. at middle; back legs 185 ft. by 5 ft. diam. at middle; outboard reach 60 ft.; two 15 by 15 engines for hoisting and two 18 by 16 engines for traversing. The legs on the right are also of 150-tons capacity, erected at one of the Royal Dockyards by Cowans, Sheldon & Co. All motions are controlled by one man.



HIGH POWER STEAM AND ELECTRIC WHARF AND SHIPYARD CRANES.

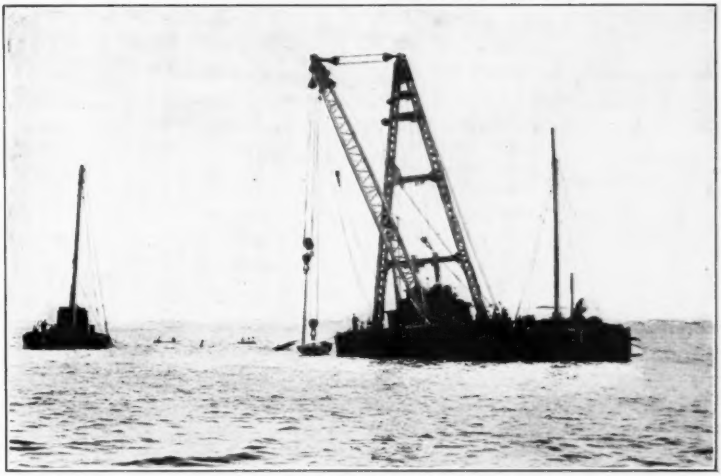
The one on the left is a 150-ton steam wharf crane, built by Cowans, Sheldon & Co., for the Trustees of the Clyde Navigation; radius 65 ft., weight 370 tons. The one on the right is a 125-ton electric derrick crane lately built for Scott's Shipbuilding & Engineering Co., Ltd., Greenock, by George Russell & Co., Motherwell. Lifts 120 tons at radius of 70 ft. and with light-purchase gear handles 10 tons at 98 ft.; minimum radius 25 ft.; hoisting speed 5 ft. per minute with 120 tons and 40 ft. per minute with 10 tons. 50-h.p. motor for main hoist and derricking motions, 35-h.p. for light hoist and slewing. All enclosed tramway type. All motions controlled by one man.

lightness and the compactness attainable (though the radius of action is of necessity restricted) for even the largest capacities make this crane very useful for wrecking and general shipyard work. The most notable of these cranes is the Monarch, owned by the Merritt Wrecking Company; and, with a capacity of 275 gross tons, it is unique in size among floating craft of this character.



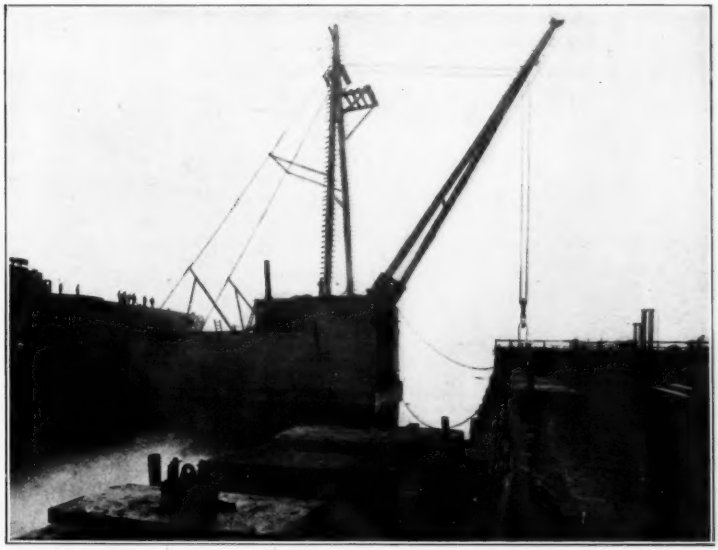
SHEAR LEGS, NEWPORT NEWS DRYDOCK & SHIPBUILDING CO., NEWPORT NEWS, VA.

Citations could be multiplied of floating cranes with distinctive features, for nearly all have some modifications introduced by the designer or to meet some special requirement; but reference to the accompanying photographs will show how widely these machines



WRECKING CRANE "MONARCH," 275-TONS CAPACITY, AT WORK RAISING THE "GEN. SLOCUM."

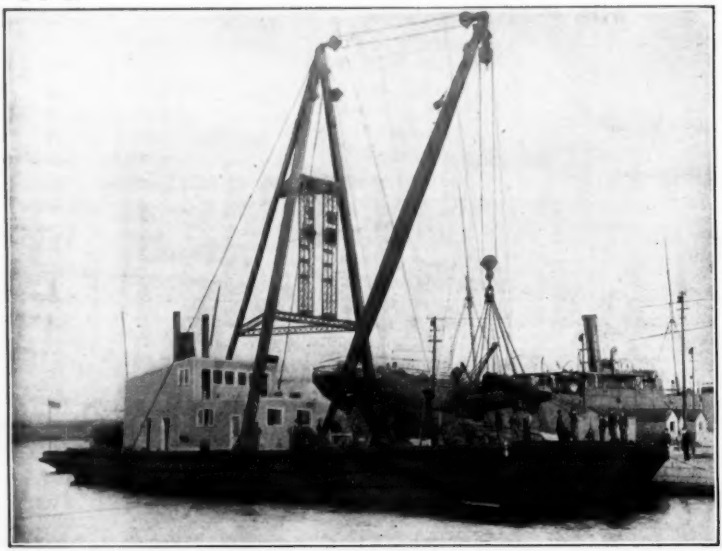
Merritt-Chapman Wrecking Co.



SEVENTY-FIVE-TON WOODEN FLOATING CRANE AND FLOATING DRYDOCK, COMBINED.

Built by Moran Shipbuilding Co., Seattle, Wash., and used in their yards.

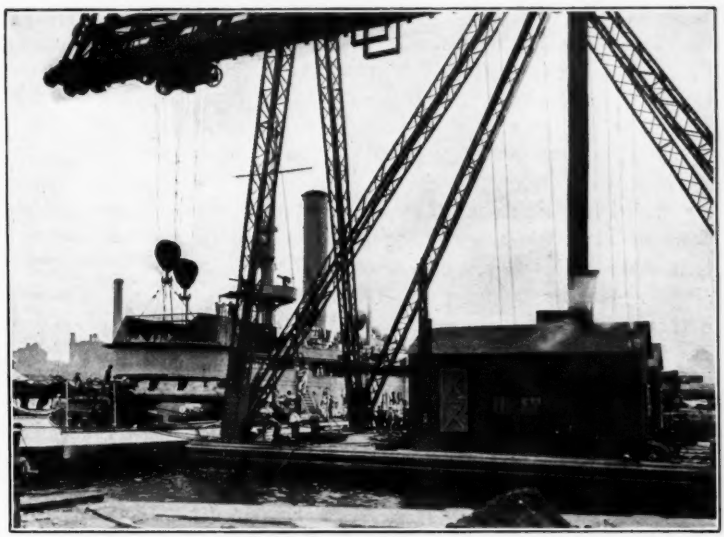
differ when a comparison is made between the 40-ton structure composed of a horizontal beam supported upon an elaborate revolving base, and the 75-ton wooden jib crane used by the Moran Shipbuilding Company, not only as a crane proper, but as a floating drydock as well as for small craft. They are shown together on the preceding page.



ONE-HUNDRED-TON SWINGING-JIB FLOATING CRANE, U. S. NAVY YARD, NORFOLK, VA.
Built by Snare & Triest.

There is one construction, however, in this class which calls for a particular description for, to my mind, it marks at once the culmination in crane-building practice and forms the most unique example of the general usefulness to which such a machine, properly designed, can be placed. This is the 100-ton steel floating crane employed in the building and the overhauling of naval vessels at the United States Navy Yard at New York. The simplicity in its design is a most striking feature, for it is made up of a horizontal truss, 210 feet 6 inches in over-all length, supported by eight inclined struts, of a light appearance but of unusual strength and stiffness, which are fastened through massive connections to the four corners of the steel pontoon. This is 60 feet wide, 100 feet long, and 11 feet 3 inches deep. The trolley runway has a total length of 190 feet, and the single compact trolley supports the two ponderous blocks, each controlled independently, which are capable of sepa-

rately lifting and handling a nominal weight of 50 gross tons, but which can in cases of emergency transport with absolute safety a load of 134,400 pounds. The engines and boilers are installed in the port and starboard sides respectively, and the middle portion, carefully separated from the remainder of the pontoon by water-tight bulkheads, is reserved for the massive counterweight device, which balances (by means of an automatically operated throttling engine) the load on the blocks, in every position, and with such precision that the deviation of the plane of the deck from that of the horizontal never exceeds 1 degree and 30 minutes. In the extreme position the center of the blocks is 45 feet from the edge of the end of the pontoon, and they are capable of being lowered from their highest position, which is 64 feet above the deck, to a point 22 feet below it. For supporting and conveying the loads for which this structure was designed there is installed 5,565 feet of plough-share



ONE-HUNDRED-TON PONTOON CRANE WITH 120-TON TURRET ON THE BLOCKS, N. Y. NAVY YARD.

Built by Brown Hoisting Machinery Co.

steel rope 1⅛ inches in diameter; and 48 steel sheaves, exclusive of the 4 in each block, each 4 feet in diameter, serve as guides for this enormous length of cable.

The uses to which this craft has been put since its acceptance on July 30, 1903, have been more numerous and more diverse than

those of probably any other crane in the world. It has placed in position armor plate for the U. S. S. Connecticut; it has removed and replaced, without a single mishap, the 13-inch guns, the 100-ton turrets, and other heavy ships' equipment of over a dozen war vessels; it has set the granite facing, and provided the power for dressing it, on a pier 65 feet wide and 500 feet long; it has removed the piling from an old quay wall obstructing the ways from which the Connecticut was launched; and in a score of other instances proved an invaluable adjunct in the operation of this most important naval plant. That it is economical in working is shown by the fact that there was actually expended $200 for taking off a defective 13-inch gun from the U. S. S. Kentucky, conveying it on the deck (which is capable of sustaining a load of 300 gross tons with a 2-foot freeboard coincident with a full load on the blocks) to Jersey City, there unloading it and bringing back a new one and replacing it in its proper position. The saving thereby resulting is rather remarkable, for the lowest bid from a private concern was $4,000 for the job. That its importance is universally recognized is amply verified by an offer of $250,000—or two and one-half times its cost to the Government—made by a European state when, early in 1903, darkening war clouds began to threaten the peace of the world.

Such is the machinery equipment for one department at the disposal of American shipbuilding concerns, and that for the others is in no whit inferior. Why then need pessimists decry American maritime-construction work? Undoubtedly as soon as capitalists deem all conditions opportune (and I am firmly of the mind that they have already so decided) for active participation in the building of vessels for the ocean and coastwise carrying trade, there will be no difficulty experienced in producing finished craft at prices which will guarantee a paying profit, and at the same time be no more expensive than foreign constructions to the shipowners.

THE SUPERHEATING OF STEAM, AND ITS INFLUENCE ON ENGINE ECONOMY.

By R. M. Neilson.

In a preceding paper, Mr. Neilson reviewed the leading types of apparatus and modes of superheating. He now discusses the results secured by their use.—THE EDITORS.

II. THE INCREASE OF EFFICIENCY BY THE USE OF SUPERHEAT.

IT is generally acknowledged that the use of superheated steam raises the efficiency of a steam engine, be it reciprocating or turbine. Why it raises the efficiency is a question which is being continually asked but which has not yet received an answer of general acceptance. One reason often urged to explain the increase of efficiency with reciprocating engines is that an important cause of loss with such engines—especially with certain types—is leakage past the valve or valves, and that the escape of wet steam through very narrow passages is greater than that of dry steam, thus giving an advantage to superheated steam, which will always be dry—at least, till it gets into the cylinder. Certain experiments that have been made seem to bear out this view; but hardly enough is known on the subject to enable us to say more than that this is a possible cause.

Another reason which seems to be well established for the increase of efficiency with reciprocating engines is that, when saturated steam is used, a great quantity is wasted by condensing on entering the cylinder and remaining condensed till exhaust takes place. The reason for the condensation is that the metal surfaces with which the live steam comes into contact have just previously been in contact with the exhaust steam. When superheated steam is employed in place of saturated steam, it is of course cooled by contact with the cold metal surfaces, but it loses less heat than does the saturated steam, in spite of the fact that with the superheated steam there is a greater difference of temperature between the steam and the cold surfaces than with the saturated steam.

This greater loss of heat by the saturated steam is due to the fact that with the saturated steam there is always a film of moisture (sometimes more than a film) covering the surfaces with which the entering steam comes into contact. Even if the saturated steam arrives at the

engine dry, it has no heat to give up to dry the surfaces wetted by the previous exhaust, except by condensing. Now this film of water serves as a ready means of transferring heat from the steam to the metal. The steam is therefore robbed of much more heat than it would lose if the surfaces were dry. When superheated steam is used, the surfaces are at once dried by the steam which without condensing can spare heat which can be used in evaporating the moisture on the metal surfaces. Thereafter, with the surfaces dry, the steam gives up to them comparatively little heat.

With turbines the gain of efficiency with superheated steam cannot be due to this cause (prevention of initial condensation), for in a turbine, getting a uniform supply of steam, each part of the turbine comes in contact with steam of only one temperature. It is true that if the supply of steam is not uniform, but arrives in puffs, or if the initial steam pressure is constantly being changed to suit the load, or if the amount of superheat in the steam varies—then each part of the turbine will not come into contact always with steam at the same temperature; but the conditions conducive to initial condensation existing in a reciprocating engine are not approached. In a turbine of the Parsons type there is no doubt that the prevention of the deposit of water on the inside of the turbine casing during the early stages of expansion, by the use of superheated steam, will reduce the transfer of heat to the casing, and so diminish the radiation losses; but not more than a small part of the increase of efficiency due to superheating can be attributed to this cause. The chief cause of the increase of efficiency in turbines due to superheating is probably the diminution of fluid friction within the turbine.

This fluid friction in steam turbines is a very important item, and it is found that dry steam causes much less friction than wet steam at the same pressure. The superheat given to the steam is usually not sufficient to keep it dry till it leaves the turbine. In fact, with de Laval turbines using superheated steam, the superheat is usually all gone and the steam wet before the fluid reaches the turbine wheel. Nevertheless, the fact that the steam is dry during part of its expansion and less wet than it would otherwise be during the remainder of its expansion, may cause a very considerable diminution of friction. Of course, the work expended in friction in a steam turbine is not altogether lost; but it would be going beyond the scope of this article to discuss the utilisation of friction-produced heat.*

It is sometimes asserted that the reduction in steam consumption

* Those interested in this question are referred to *The Engineer*, London, Sept. 4, 1903, page 240.

brought about by superheating the steam to a moderate extent, say by about 150 degrees F., is largely due to the increased volume given to the steam when being superheated. It is true that a small percentage additional heat given to steam in superheating it produces a large increase in its volume; but it must be remembered that superheated steam expands in a different way from saturated steam, and it must not be assumed that the amounts of work to be got from saturated steam and from superheated steam respectively during expansion are proportional to the respective volumes before expansion. As a matter of fact, the adiabatic expansion line for superheated steam falls much more rapidly than the adiabatic expansion line for saturated steam. The additional volume obtained by superheating is cheaply bought for heat and is cheaply sold for mechanical work. There is a thermodynamic gain, but it is very slight and does not account for more than a small part of the reduction in steam consumption.

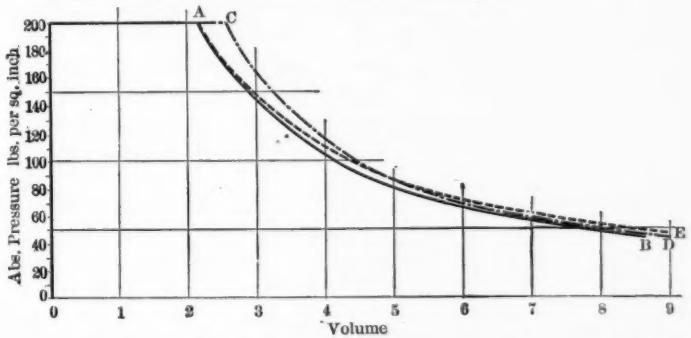


FIG. 1. EXPANSION OF SATURATED AND SUPERHEATED STEAM COMPARATIVELY SHOWN.

Adiabatic expansion curves for saturated and for superheated steam are given in Figure 1, where they can be compared. The full line A B represents the adiabatic expansion line of saturated steam starting at 200 pounds per square inch absolute. The chain line C D represents the adiabatic expansion of the same weight of steam which is superheated at 200-pounds pressure absolute from the boiling point 382 degrees F. to 510 degrees F. and before it is allowed to expand adiabatically.

When saturated steam expands adiabatically some of it condenses and the volume is reduced in consequence. If, in the case in question, sufficient heat had been supplied to the saturated steam during expansion to prevent condensation but not to superheat the steam, the expansion curve would have been as shown by the dotted curve

AE. Now the superheated steam in question will not remain superheated throughout the expansion: this is well known. As a matter of fact, the superheat will be gone by the time it has expanded to a pressure of about 70 to 100 pounds absolute (the precise pressure depends on the laws of expansion of superheated steam which we do not know with exactness). The line of expansion of the superheated steam therefore cuts the dotted line AE at this pressure as shown in the figure; and from this point the steam originally superheated expands as saturated steam and keeps below the dotted curve A E, getting continually wetter and wetter as it expands.

If the weight of steam dealt with is one pound, the figures in the diagram indicating volume will represent cubic feet. The curves will however represent the expansion of any weight of steam whatever, the horizontal row of figures representing relative volumes. The expansion curves have been stopped at about 40 pounds absolute in order to keep the diagram within reasonable dimensions. If however the diagram had been continued to a very low pressure, the curves AB and CD would have been found to keep close together for the remainder of their lengths.

It will be seen that, although the superheated steam has at the start a volume considerably greater than the saturated steam, the ratio of the volumes rapidly diminishes. The work got out of the superheated and saturated steam respectively when expanded to any pressure and discharged at that pressure can be obtained by drawing a horizontal line at that pressure to meet the expansion curve. The area of the figure enclosed by the expansion curve, this horizontal line, the horizontal line at 200-pounds pressure, and the line of zero volume, will then represent the work got out of the superheated or saturated steam as the case may be.

If the lower pressure be taken at 0.6 pounds absolute, which means an exceedingly good vacuum for a steam engine, the work done by the superheated steam will be found to be only about 6 or 7 per cent. greater than the work done by the saturated steam. As about 5 per cent. additional heat has to be supplied to superheat the steam, it will be seen that the thermodynamic gain is very slight. The thermodynamic gain is better seen on an entropy temperature diagram; but a pressure-volume diagram has been selected in this case in order to show the relative volumes.

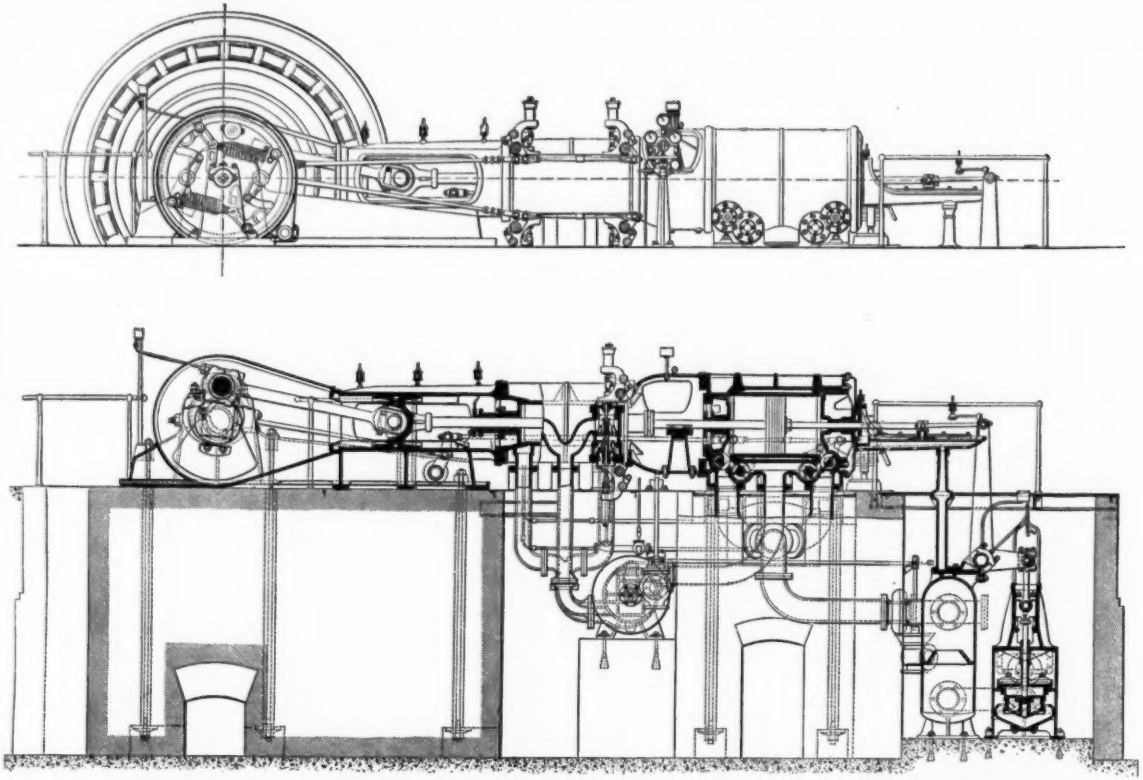
In my opinion the gain obtained by moderate superheating cannot be attributed, except to a small extent, to increase of volume, and is really due in the case of turbines to the reduction of friction and in the case of reciprocating engines largely at least to reduction of

initial condensation. As a good vacuum with reciprocating engines is conducive to great initial condensation, it would seem that superheating should be more beneficial to reciprocating engines when a good vacuum is used than when a poor vacuum is used.

The greater part of the economy to be derived from the use of superheated steam can be obtained without exposing the engine to high temperatures, by compounding and employing a reheater to superheat the steam passing from the high-pressure to the low-pressure cylinder. The cut-off in a single-expansion engine is of course much earlier than in the high-pressure cylinder of a compound engine having the same total range of expansion. For this reason it requires very much less initial superheat to keep the steam dry to exhaust in the high-pressure cylinder of the compound engine than in the single-expansion engine. Moreover, the steam will suffer less loss of heat in entering the high-pressure cylinder of the compound engine than in entering the cylinder of the single-expansion engine, because the former cylinder is at higher temperature than the latter and this will still further reduce the amount of initial superheat required by the compound engine compared with the single-expansion engine. If the steam exhausting from the high-pressure cylinder of the compound engine is superheated before entering the low-pressure cylinder, so as to carry it through that cylinder dry, the compound engine will receive the same benefit by superheating as the single-expansion engine so far as regards dryness of the cylinder walls, etc.

If the steam is not superheated sufficiently to carry it dry right up to the point of exhaust, the comparison made above still holds good. That is to say, if the initial superheat in the case of the single-expansion engine is sufficient to keep the steam dry to a certain point in the stroke, then in the case of the compound engine a much less initial superheat, together with a drying and superheating of the steam in the reheater, will give equivalent advantages as regards dryness. The amount of superheat which would need to be given initially to the steam in a single-expansion engine to carry it through dry to the exhaust would, of course, be very great with a high steam pressure, especially for a condensing engine. There is, however, a thermodynamic advantage in superheating the steam all at once instead of at two stages.

This is due to the heat for superheating being absorbed by the steam at a higher average temperature. Whether this advantage is sufficient to counterbalance the disadvantage of the higher initial temperature is an open question. In many cases, however, an existing compound engine has to be used which certainly cannot stand



FIGS. 2 AND 3. HORIZONTAL TANDEM-COMPOUND ENGINE, WORKING WITH SUPERHEATED STEAM ON THE SCHMIDT SYSTEM.
Cylinder 15 and 24 by 28 in.; 140 revolutions; 140-lb. pressure, temperature at engine 750° F. Built by Easton & Co., Ltd., London and Erith, for Brantham Works of the British Xylonite Co., Ltd. By Courtesy of *The Engineer*, London.

very highly superheated steam, and this stage superheating is in such a case the best means of obtaining the maximum economy.

With single-expansion engines using superheater steam the cylinder may be jacketed with the superheated steam. This jacket will then act somewhat like the reheater of the compound engine and allow a lower initial superheat temperature to be employed without loss of economy. With compound engines using superheated steam, the high-pressure cylinder is sometimes jacketed with the superheated steam and a reheater employed in addition to this. A jacket should, however, be employed only when sufficient initial superheat cannot be given to keep the steam dry till it leaves the cylinder. Even when this condition is barely fulfilled, the jacket may cause more loss than gain. There is no excuse for a jacket on the low-pressure cylinder of a compound engine using superheated steam.

With a triple- or quadruple-expansion engine, the steam can be superheated before use in each of the three or four cylinders (or sets of cylinders). It will be advisable, however, whenever possible, to omit the last stage reheater in the case of the triple-expansion engine, and the last two reheaters in the case of the quadruple-expansion engine, and in place of these to give the steam additional superheat at the first reheater. It is not likely that quadruple-expansion reciprocating engines will ever be built for use with superheated steam; but existing engines may have to be adapted to use it.

It is usually not convenient to superheat the steam in a reheater by a fire or by products of combustion from a fire. It is therefore common practice to employ as a heating agent some of the steam which comes from the primary superheater. The reheater may be a box in which are placed coils of tube through which passes the high-temperature steam. The steam to be reheated passes through the box and outside the coils of tube. The high-temperature steam transfers to the low-temperature steam some of the heat it has acquired, without any serious waste.

A good example of a compound engine using superheated steam with a reheater between the cylinders is shown in Figures 2, 3, and 4.

The details of the receiver in which the steam is heated between the high- and low-pressure cylinders are shown in Figures 2, 3 and 4. This engine was one of two constructed by Messrs. Easton & Co. (now Easton & Anderson) of Erith and London, for the British Xylonite Co., Ltd. The cylinders are 15 and 24 by 28 inches and the revolutions per minute 140. The high-temperature steam from the superheater is passed through the tubes in the receiver as shown in Figures 3 and 4. There are 55 tubes, 20 millimeters internal diame-

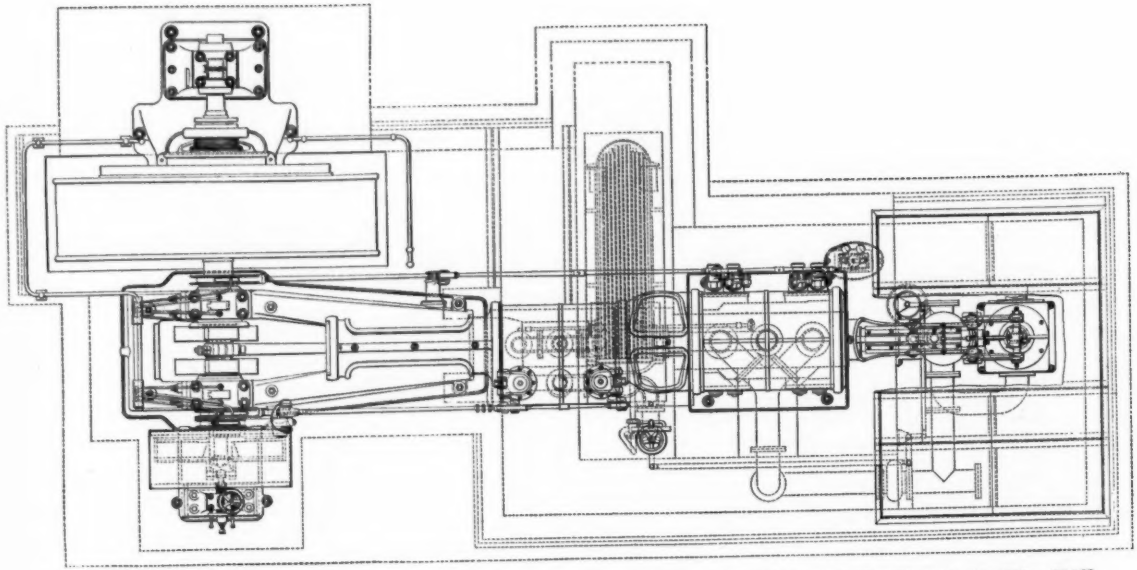


FIG. 4. HORIZONTAL TANDEM-COMPOUND ENGINE WORKING WITH SUPERHEATED STEAM ON THE SCHMIDT SYSTEM. PLAN.
By Courtesy of *The Engineer*, London.

ter and 28 millimeters external diameter. The tubes are of course of unequal length, as can be seen from Figure 4. The average length is about 7 feet bent or 14½ feet unbent. The total length of the receiver, including the valve chamber at the end, is 9 feet 1 inch and the diameter is 2 feet 7 inches. The steam after passing through the tubes, which are all in parallel, and after having its temperature thus considerably reduced, proceeds to the high-pressure cylinder. The exhaust from the high-pressure cylinder is taken to the receiver and makes contact with the outside of the tubes within the receiver. A plate is arranged centrally within the receiver from the tube plate to near the curved ends of the tubes. This causes the steam which has to be reheated to pass twice along the length of the receiver box. Figures obtained during a test of this engine by Prof. Ewing are given in Tables VI and VII.

Figures will now be given to show the reduction in steam consumption to be brought about by superheating. Tables I, II and III refer to turbines and IV, V, VII and VIII to reciprocating engines.

TABLE I.*—TEST OF 500-KILOWATT TURBO-ALTERNATOR CONSTRUCTED BY MESSRS. C. A. PARSONS & CO. FOR THE CORPORATION OF BLACKPOOL.

Pressure of steam above atmosphere at stop valve in lbs. per sq. in.	Superheat at stop valve in degrees F.	Vacuum in turbine cylinder in ins. of mercury Bar.=30"	Revs. Per min.	Load in Kilowatts.	Steam used. lbs. per hr.	lbs. per K.W. hr.
146	70	27.1	2,500	515	11,000	21.35
150	0	27.0	2,500	502	11,600	23.1
135	0	27.3	2,500	497	11,953	24.0
133	66	27.3	2,500	507	10,693	21.1

TABLE II.*—SUMMARY OF TESTS OF A 300 B. H. P. DE LAVAL STEAM TURBINE AT TRENTON, N. J., U. S. A.

Duration of test in hours.	Average steam pressure before governor valve in lbs. per sq. in.	Average steam pressure after governor valve in lbs. per sq. in.	Average vacuum in inches of mercury.	Barometer in inches of mercury.	Average temperature of room in degrees Fahr.	Average superheat before governor valve in degrees Fahrenheit.	No. nozzles open.	Revolutions per minute of generators.	Average brake horse power.	Lbs. of steam per hour.	Lbs. of steam per B.H.P. hour.
6	207.0	198.5	27.2	30.18	83	84	8	750	352	4906	13.94
2	207.4	197.0	27.4	30.07	90	64	7	756	298.4	4282	14.35
6	201.5	197.2	27.4	29.79	89	13	5	745	196.2	3047	15.53
4	206.4	196.9	26.6	29.92	90	0	8	747	333.0	5052	15.17
2	207.3	196.5	26.8	29.90	97	0	7	746	284.8	4430	15.56
2	207.6	195.8	27.3	29.83	97	0	5	751	195.2	3229	16.54
3	201.5	197.9	28.1	29.81	80	0	3	751	118.9	1950	16.40

Figures showing the percentage reductions in steam consumption due to superheating have been calculated or collected by the author

* The Steam Turbine, by R. M. Neilson. Longmans & Co.

from a number of tests made in Great Britain, the Continent of Europe, and America, and are tabulated in Tables III and VIII.

TABLE III.—REDUCTION IN STEAM CONSUMPTION IN STEAM TURBINES, DUE TO SUPERHEATING. STATISTICS OBTAINED FROM A NUMBER OF TESTS.

Degrees Fahrenheit of superheat.	Percentage reduction of steam consumption.	Percentage reduction per degree Fahrenheit.
13	6.1	0.47
50	8.0	0.16
60	5.4	0.09
66	12.1	0.18
70	7.5	0.11
84	7.7	0.09
100	14.0	0.14
140	12.6	0.09
150	19.0	0.13
200	23.0	0.115
260	24.5	0.09

TABLE IV.—REDUCTION IN STEAM CONSUMPTION IN RECIPROCATING STEAM ENGINES DUE TO SUPERHEATING. STATISTICS OBTAINED FROM A NUMBER OF TESTS.

Degrees Fahrenheit of superheat.	Percentage reduction of steam consumption.	Percentage reduction per degree Fahrenheit.
31	7.86	0.25
40	8.65	0.22
50	12.00	0.24
100	20.55	0.20
150	13.00	0.09
216	36.4	0.17
225	33.7	0.15
225	33.1	0.15
440	30.9	0.07

The figures in Table VI are obtained from Prof. Ewing's report as are also the figures in Table VII, which belong to the same test. The boiler was of the Lancashire type and the superheater of the Schmidt independently fired type. The steam was reheated between the high- and low-pressure cylinders, the heat being obtained from the superheated steam on its way from the superheater to the high-pressure cylinder. The engine is illustrated in Figs. 2, 3, and 4. The curve of total steam consumption of the engine is given in Figure 5, the position at which actual measurements were taken being indicated.

The reduction in steam consumption does not of course necessarily represent the reduction in coal consumption. Heat must be given to the steam to superheat it. If this heat is supplied by the waste gases leaving the boiler, which would otherwise pass away unused, then the superheat is obtained for nothing and the table represents the saving in coal as well as in steam. It is obvious, however, that we are not in this case making a fair comparison of the merits of superheated and of saturated steam, as when we use the latter we are sending away our waste gases at a higher temperature than with the former while there is no good reason why we should do this.

One means for getting at the reduction of coal consumption which

TABLE V.*—TESTS BY PROF. SCHRÖTER OF HORIZONTAL COMPOUND TANDEM RECIPROCATING STEAM ENGINE AT GHENT.

	Indicated load in horse power.	Length of trial in minutes.	Consumption of steam per hour in kilograms.	Consumption of steam per hour per I.H.P. in kilograms.	Temperature of steam at introduction in degrees Centigrade.	Equivalent consumption of saturated steam per I.H.P. hour in kilograms.	Percentage of economy by superheating on the consumption of saturated steam.	Consumption of heat per I.H.P. per hour in calories.
Saturated Steam Varying Power	312.17	60.16	1902	6.09	180.7	...	...	4029
	273.02	61.04	1560.8	5.72	180.1	...	...	3783
	219.03	57.54	1197.7	5.47	180.3	...	...	3618
	167.65	54.96	885.5	5.28	178.7	...	...	3490
	166.77	50.34	526.6	5.37	178.9	...	...	3550
	21.50	53.23	131.9	6.13	....	...	...	4054
Superheated Steam Varying Power	314.22	48.15	1527.3	4.86	299.6	5.28	13.3	3493
	268.84	59.69	1249.3	4.65	305.8	5.07	12.1	3355
	220.24	50.82	12	4.46	306.4	4.87	11	3220
	167.65	64.66	728.2	4.34	304.3	4.73	10.4	3130
	119.36	54.96	515	4.31	304.6	4.70	12.5	3108
	222.87	73.70	1170.5	5.25	204.3	5.34	2.4	3534
Constant Power Varying Superheat	223.90	58.05	1116.2	4.99	233.6	5.19	5.1	3430
	220.29	47.61	1065.6	4.84	263.4	5.14	6	3397
	219.75	337.54	977.6	4.45	303.1	4.85	11.3	3206
	215.19	57.18	864.9	4.02	352.8	4.52	17.3	2992

TABLE VI.—TESTS BY PROF. EWING OF A HORIZONTAL TANDEM TWO-CYLINDER COMPOUND ENGINE OF 300 H. P. BUILT BY MESSRS. EASTON & COMPANY, LTD., AT THE BRANTHAM WORKS OF THE BRITISH XYLONITE COMPANY, NEAR MANNINGTREE.

Trial No.	Date of trial.	Indicated horse-power.	Electrical horse-power.	Ratio of electrical horse-power to indicated horse-power.	Pounds of steam: Total per hour.	Pounds of steam: Per indicated horse-power hour.	Pounds of steam: Per kilowatt hour.
I	Dec. 16, 1902	312	255	.82	2,925	9.4	15.4
III	Dec. 17, 1902	239	192	.80	2,150	9.0	15.0
II	Dec. 16, 1902	175	130	.74	1,670	9.5	17.2
IV	Dec. 17, 1902	47	4.8	..	975	..	...

* *Power*, June, 1903, pp. 288-293.

TABLE VII.—FURTHER PARTICULARS OF THE SAME TEST.

	Test No. I	Test No. III	Test No. II	Test No. IV
Boiler pressure, lbs. per sq in.....	141	141	142	140
Corresponding saturation temperature..	361° F	361° F	361½° F	360° F
Temperature at superheater.....	800° F	790° F	810° F	790° F
Pressure at engine, lbs. per sq. in.....	134	135	139	138
Temperature of engine, before passing re-heater	737° F	734° F	761° F	...
Temperature at engine, after passing re-heater	554° F	590° F	603° F	...
Vacuum, inches of mercury*.....	27¼	28	28	29
Revolutions per minute of engine.....	140	140	140½	140

* The height of the barometer was not stated.

TABLE VIII.*—TESTS BY PROF. D. S. JACOBUS OF RICE & SARGENT HORIZONTAL CROSS-COMPOUND RECIPROCATING STEAM ENGINE.

Date of test, 1903.....	May 27.	June 19.	July 17.	July 24.
Condition of steam. Superheated or saturated.....	Sup.	Sup.	Sup.	Sat.
Length of test in hours and decimals of an hour.....	5.15	6.033	6.00	6.50
Water feed to boiler in pounds per hour, corrected for leakage.....	4633	4018	2684	5630
Pressure of steam near throttle in pounds per square inch.....	141.2	142.4	145.6	145.1
Vacuum at condenser in inches of mercury.....	25.80	26.79	26.81	25.24
Barometric pressure in inches of mercury.....	30.16	29.80	30.01	30.00
Temperature of steam at the engine throttle in degrees F.....	713.7	736.3	756.8	....
Amount steam was superheated at the engine throttle in degrees F.....	352.5	374.5	393.3	....
I.H.P. developed by engine.....	474.5	420.4	276.8	406.7
Water consumption in lb. per hour per I.H.P.....	9.76	9.56	9.70	13.84
Heat consumption in B.T.U. per min. corresponding to the heat in steam at the throttle valve, and the max. temp. of feed water—standard of Inst. of Civil Engineers (Great Britain).....	205.0	203.7	208.8	248.2
Coal per hour per horse-power on basis of the heat consumption recommended as a standard by Inst. of Civil Engineers (Great Britain.) In this the loss due to radiation of the steam pipe from the boiler to the engine is not charged against the engine, and it is credited with the maximum temperature at which it can return the feed water to the boiler.....	1.265	1.257	1.288	1.497
Actual water evaporated and superheated per pound of dry coal in test made June 19.....		7.09		
Actual coal burned per hour per I.H.P.		1.348		

* Paper read by Prof. Jacobus before the American Society of Mechanical Engineers, 1903. *Power*, Jan., 1904, pp. 39-42.

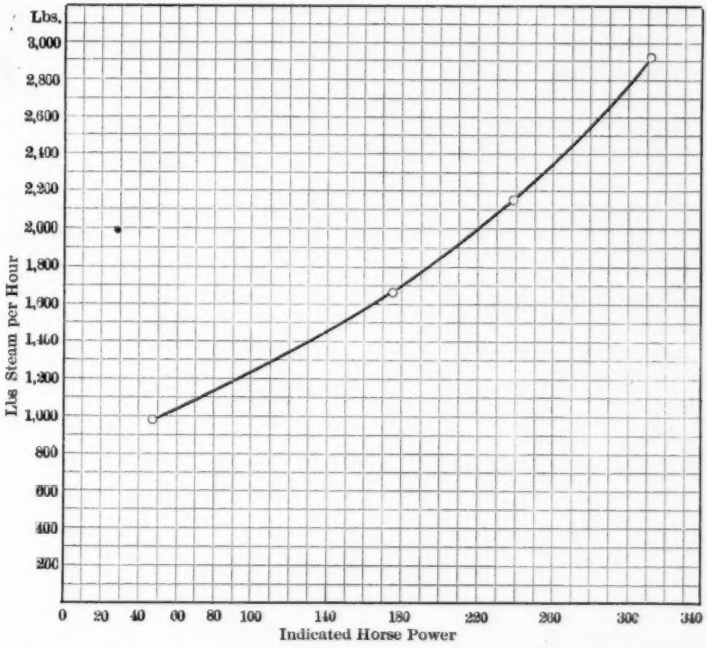


FIG. 5. TOTAL STEAM CONSUMPTION OF 300-HORSE-POWER COMPOUND ENGINE USING SUPERHEATED STEAM.

can be expected from figures giving the reduction in steam consumption is to find the number of thermal units in one pound of the superheated steam and subtract from this the number of thermal units in one pound of the feed water. Then find the number of thermal units in one pound of the saturated steam and subtract from this the number of thermal units in one pound of the feed water. The ratio ot these results is the ratio of the coal consumption per pound of steam in the two cases, if the efficiency of the boiler and superheater in the one case is equal to the efficiency of the superheater in the other case. If, therefore, we multiply this ratio by the ratio of steam consumption per horse-power in the two cases, we get the ratio of coal consumption in the two cases. This means of getting at the relative coal consumptions involves the assumption that the efficiency of the boiler in the case of the saturated steam is equal to the efficiency of the boiler and superheater in the case of the superheated steam. These efficiencies, of course, may not always be the same. In the test of a Lancashire boiler and Schmidt superheater by Prof. Ewing, the

efficiency of the boiler alone was 70 per cent., and that of the combined boiler and superheater only 63 per cent.*

If the superheating tubes are heated by the hot gases passing from the boiler to the chimney, which, when the superheater is not in use, pass direct to the chimney, then the efficiency of the boiler and superheater will probably be greater than the efficiency of the boiler alone when the superheater is not in use.

When comparing the best results to be obtained with saturated steam with the best to be obtained with superheated steam, it must be remembered that if we use no superheater we can often employ a feed-water heater which can utilize a considerable portion of the heat of the gases leaving the boiler and send the gases away at a low temperature; whereas, if the gases leaving the boiler have to heat a superheater, they cannot in most cases be used for a feed-water heater. Now the temperature of the waste gases cannot be lowered below the lowest temperature of the fluid being heated, whether this is steam or water; and the temperature of the steam entering the superheater is obviously greater than the temperature of the water entering the feed-water heater. Therefore the waste gases must pass away at a higher temperature when a superheater is employed than would otherwise be necessary, and therefore more heat and more coal will probably be wasted.

On the other hand, it must be remembered that the use of a superheater does not necessarily prevent the use of a feed-water heater. With a boiler designed for no superheater, it ought to be impossible to heat both a feed-water heater and a superheater with the gases leaving the boiler; if it *is* possible, then the boiler has been very badly designed for its work without the superheater. But if a feed-water heater and a superheater are decided on at the start, there should be no difficulty in so designing and arranging the boiler, superheater, and feed-water heater, that all can obtain sufficient heat and the waste gases pass away at a minimum temperature.

There is a good deal of discrepancy in the results given in Tables III and VI, and there are various reasons for this. The dryness fraction of the saturated steam probably differed very considerably in the several cases and the engines were of different types and different sizes. It must be noted that an engine constructed to give the best results with saturated steam is usually unsuitable for use with highly superheated steam, and an engine designed for using highly super-

* This refers to the same test as Tables VI and VII. The efficiencies of boiler and superheater were not given by Prof. Ewing in his report but have been worked out by the writer from figures given by Prof. Ewing. The low efficiency of the superheater may have been due to its never working at more than half load during any test.

heated steam does not usually do justice to saturated steam. Steam turbines seem to have an advantage over reciprocating engines in this respect. Steam turbines of the Parsons type can be built to stand a superheat of about 150 degrees F. (steam pressure 150 to 200 pounds per square inch) without any appreciable addition to their cost and without lowering their efficiency when using saturated steam to more than a very slight extent.

As regards the life of superheaters, evidence is very conflicting. This is to be expected, as the life of a superheater must necessarily depend largely on its design and on the arrangements used for heating it. There seems no reason why a well designed and well arranged superheater should not last as long as a water-tube boiler.

As regards cost of piping for superheated and saturated steam, it should be noted that, although the volume of superheated steam is greater than that of saturated steam, the superheated steam experiences less friction in passing along pipes; and it is therefore possible with the same pipe and the same loss of pressure, to give superheated steam a higher velocity than saturated steam. As a less weight of superheated steam than saturated steam is required per horse-power hour at the engine, the same pipe will convey with a given loss of pressure at least as much power (measured at the engine) in superheated steam as in saturated steam.

To sum up the gains and losses to be expected by adopting superheating, these are—

Losses.

1. Initial cost and upkeep of superheater.
2. Increased initial cost and upkeep of engines.

Gain.

Reduced coal consumption.

If, with 150 degrees F. of superheat, the coal consumption be reduced from 1.5 pounds to 1.275 pounds per brake-horse-power per hour, that is 15 per cent., the gain with an engine of 1,000 brake-horse-power working 2,500 full power hours per year will be 251 tons. With a good design and arrangement of superheater and a suitable engine, this gain ought easily to wipe out the losses due to the interest on the increased cost of the plant and the increased depreciation and cost of upkeep, and leave a substantial balance of net saving.

In conclusion, I would express the opinion that there is no doubt that with properly designed plant superheating pays. What is the best paying superheat is, however, a question which it seems impossible to answer with any degree of accuracy with the data at present at our disposal.

PRACTICAL INVESTIGATIONS IN THE GAS-TURBINE PROBLEM.

By Charles E. Lucke, Ph. D.

The gas turbine has been regarded as the logical successor of the steam turbine, and already numerous devices have been produced, on paper, to convert the energy of the confined products of combustion into mechanical power. Dr. Lucke examines the thermodynamic principles involved in such devices, and shows, as the result of exhaustive experiments, conducted in the mechanical laboratory of Columbia University, that this conversion is not effected by free expansion in simple nozzles. A portion of the potential kinetic energy developed by the combustion, and readily transformed into work when the products of this combustion are allowed to expand in the cylinder of a reciprocating engine, is not so recovered when these same products expand through the nozzles of an ordinary turbine; and the difference is so great as to make the latter a failure commercially. This Dr. Lucke considers the answer to the question, and it is as definite as it is unfavorable. It refers, of course, wholly to the gas turbine. The investigations do not cover a mixture of combustion gases and steam. An examination of the principles of free expansion, as discussed in this paper, will go far to prevent mistaken claims from receiving unwarranted support, and to direct the work of engineers and inventors into those channels in which success is more probable.—The Editors.

AN engine carrying a rotating part, provided with vanes or buckets on which a jet of fluid may impinge to cause rotation, is in brief a turbine. When water is the fluid, custom has sanctioned a somewhat different classification. The bucket wheels of Pelton and Doble have seldom been called turbines, yet they are more truly turbines than some other water wheels that have received the name. In these, water under pressure issues from a nozzle into the atmosphere, thus converting pressure head into velocity, giving outside the nozzle a mass of water with no pressure but moving with high velocity. By contact with the buckets, the water is brought to rest and the bucket moved with force enough to overcome some resistance.

This receiving of a jet of fluid and bringing it to rest is the function of the rotating part of every turbine, and work is done by this member only because it can bring to rest the jet of fluid once formed with a given velocity. Velocity is given to any fluid, liquid vapor, or perfect gas, by forcing it to flow through an orifice or nozzle from a place of high pressure to one of low pressure. This process, whereby the fluid is given a velocity by a pressure drop through an orifice, is

very thoroughly understood for incompressible fluids such as water, where there is no change in density and hence no expansion of the mass with the change of pressure. Should, however, the fluid be a perfect gas, it will change density with the pressure change and suffer an expansion in addition to the phenomena apparent in constant-density fluids. Such expansion through a nozzle is termed "free expansion."

The laws governing change of state in the fluid by free expansion are but little understood, and nearly all computations that have been made thus far have involved some assumption not experimentally verified. To the two previous cases (involving the velocity due to pressure drop of a constant-density fluid, and the change of density due to the same pressure drop), free expansion of a vapor adds an additional phenomenon—that of partial condensation, or possible superheat. Flow of fluids then presents three sets of phenomena.

LIQUIDS.

1.—Velocity due to pressure drop, with density constant and constancy of liquid state.

PERFECT GASES.

1.—Velocity due to pressure drop, with density constant.

2.—Velocity due to change of density as resultant of pressure and temperature change.

VAPORS.

1.—Velocity due to pressure drop, with density constant.

2.—Velocity due to change of density as a resultant of change of pressure with the vapor remaining as vapor.

3.—Velocity due to change of state, from vapor becoming partially superheated or partially condensed.

These phenomena may be divided into (a) purely mechanical action, and (b) thermal action. The first increment of velocity, due to pressure drop with constancy of density, is a purely mechanical change; while the other two increments, due to change of density or change of state, are thermal.

The last may be a positive increment, or negative—that is, velocity may be increased or decreased as the result of this action. The extent of the change of density in free expansion, and the amount of superheat or condensation, are dependent on the thermal characteristics of the fluid. As the kinetic energy of the resulting jet is due to all three velocity increments for a unit mass flowing, that part of the resultant kinetic energy that is due to free expansion of a perfect gas or vapor is also dependent on the thermal character-

istics of the fluid. This particular part of kinetic energy of the jet is the measure of, or is measured by, the amount of heat that has been given up by the fluid to give the mass the velocity increment due to free expansion.

The amount of heat that is transformed into work by a pressure-volume-temperature change in a perfect gas or vapor, can be known when the total heats of the fluid before free expansion and after, while still possessed of its velocity, are known, or when the law of pressure-volume-temperature change is known. Therefore positive information must be available on the above phenomena in order to know the kinetic energy or velocity and mass of the fluid in motion, and hence the work that might be done by the transfer of velocity and kinetic energy to the wheel.

The turbine engine, using expanding fluids such as steam or a perfect gas, may be said to depend for its possibilities of output and efficiency on, first, a mechanical action in the jet, and second a thermal action. The latter may be absent. The turbine may convert both potential mechanical and thermal energy into work, or only the first. No matter how perfect may be the mechanism for changing the energy of the jet into energy of the wheel, the turbine may be useless if the maximum amount of original energy of the fluid is not first converted into kinetic energy of the jet. In other words, if the designer's knowledge of free expansion is not sufficient, it may be impossible to provide means for utilizing the possibilities of the basic free-expansion phenomena in giving to the jet of fluid the maximum possible kinetic energy.

The mechanism so far used for conversion of the original potential energy of the fluid into kinetic energy of jet is the nozzle. These nozzles may be simply holes in plates of circular, rectangular, or any cross section, of any length and any degree of change in area of cross section. Practically all nozzles that have been used were designed on some assumption of the phenomena taking place in free expansion, because there is not in existence sufficient experimentally verified information to permit of a more positive method.

When the fluid used is a perfect gas, or nearly so, such as air or the gaseous products of a combustion, the turbine comes under the head of gas turbines. More particularly is the name applied to those turbines using the products of combustion from a fuel and air previously compressed. The actual mechanism of these gas turbines may cover a great range of varieties, but there are three elements to the system:—(a) A compression pump for air and fuel. (b) A

receiver for the fuel and air compressed, and pressure combustion chamber to convert the fuel and air into hot gas. (c) The turbine proper to use the hot gases.

While of course the efficiency of the system, measured by the ratio of the net horse-power output to the horse power equivalent to the heat supplied, will depend on the efficiency of the compressor and the turbine, it is dependent primarily on the efficiency of conversion of the heat of the hot gases from the fire to kinetic energy of these same gases after the expansion. If the means for executing free expansion, perchance by a simple nozzle, be such that much of the heat of the originally hot gases can become kinetic energy of the jet, the gas turbine may be good; otherwise it cannot, be the refinements of the rest of the mechanism as fine as they may.

For this heat conversion to be good, the temperature of the hot gases must be lowered in acquiring velocity; and conversely, if the temperature of the jet in motion be but little lower than that of the gases leaving the fire, the free expansion has not converted much of the fuel heat into work. Expansion in a cylinder behind a piston is termed balanced expansion, because the pressure of the gas is always balanced by a piston resistance and the mass is practically at rest. It is well-known that such balanced expansion will cool the gases, and by this cooling heat is converted into work. The computation of the amount of heat thus transformed into work is easy for balanced expansion as the problem is quite definite.

Should the temperature drop due to free expansion of the hot gases be less than that for balanced expansion, then less heat has been transformed into work, or kinetic energy. It is here that most of the propositions for operating gas turbines have involved a serious assumption. It has been taken for granted that by free expansion in a nozzle, the temperature drop would be the same as for expansion behind a piston, though no experimental verification is available.

Should it be possible to bring about a temperature drop by free expansion equal to that for balanced expansion, then the possible thermal efficiency of the gas turbine would be the same as for a corresponding gas engine—other losses in compression, jacketing, friction, etc., being equal. It is on the assumption of the truth of the above that all the predictions so frequently heard of the possible future of the gas turbine are based. Unfortunately, the experiments to determine just how to produce equivalent results by free and balanced expansion have been by far less numerous than the reiteration of statements that such equivalence must exist.

It is not within the scope of this paper to examine whether or not theoretically such equivalence can exist, nor to determine the conditions of equivalence; but a few of the experimental facts bearing on this question will serve the present purpose. Inventors of ice machines have met this problem in their work. One style of ice machine compresses air, cools it after compression to the temperature of whatever water is available, and subsequently expands the air in cylinders. The exhaust from these cylinders, for even moderate initial pressures, is cold enough to freeze water. By such balanced expansion a cooling results that is found to agree very well with that theoretically computed on an assumed law—and verifying the law, as the discrepancies are easily accounted for. This mechanism of the second or expanding cylinder is complicated and inventors have sought to substitute for it a simple nozzle to use free expansion in place of balanced expansion, assuming equivalence of results. This attempt has met with total failure, as practically no cooling has been attained, the air after passing the nozzle being only a few degrees colder than before passing. It might be urged that this is explained by the fact that the air in the system, by impact, loses its velocity and so suffers a rise equal to the temperature drop it suffered in acquiring velocity, with a slight difference due to the fact that the gas is not perfect. While there is an element of truth in this, it does not account for the whole difference observed, because water cannot be made to freeze on the nozzle itself, with air that easily freezes water on the exhaust pipe of the air cylinder operating under balanced expansion.

Holding a thermometer in the stream of air issuing from an open valve or nozzle on a compressed-air main will show, for even a pressure drop of 100-pounds per square-inch, only three or four degrees temperature change. This also may be due to impact on the thermometer raising the temperature of the moving gases by bringing them to rest on the bulb; but again this will not account for the whole difference between what is observed and what would be were this free expansion equivalent to balanced expansion. To eliminate the errors of impact as much as possible, a thermal couple stretched axially along the jet and made of fine wire has been used by the author for a measurement of the temperature of the air when moving at the maximum velocity. The maximum temperature drop for air under 100-pounds initial pressure, expanding through a steam-turbine nozzle into atmosphere, is only 30 degrees F. This result is only 12 per cent. of the temperature drop that would have resulted did the air suffer balanced expansion without gain or loss of heat.

Another instance of the same lack of equivalence in results by free and balanced expansion is found in the experiments of Tripler and Linde on the making of liquid air. In this work air highly compressed (2,000 to 3,000 pounds per square inch) is first cooled by water and then some of the air freely expanded through a hole, the discharge passing around the pipe feeding the hole. This was intended to cool the air in the pipe lower than the critical temperature for liquification under the high pressure used. The results were enormously different from the case for balance expansion, the temperature drop through the nozzle being only about ¼ degree F. per atmosphere-pressure drop, according to one report. More accurately, the results for the Linde process are shown in the following table, the initial pressure being 220 atmospheres.

Temperature approaching the nozzle.	Actual temperature drop through nozzle.
+ 30° F.	35° F.
0° F.	65° F.
— 30° F.	80° F.
— 60° F.	96° F.
— 100° F.	112° F.
— 150° F.	135° F.

Unless, by an increase of knowledge of free expansion of perfect gases, it becomes possible to produce results equivalent to those obtained with balanced expansion, there cannot be the same amount of heat transformed into work by the gas-turbine engine as by the cylinder-and-piston gas engine.

In conclusion, the situation may be summed up by saying that so far no work has been done that warrants any assumption of equivalence, and the difference is so great that the pure gas turbine, provided with the simple nozzles used by steam turbines, is a failure commercially, and can never rise above this until some method has been found to make results by free expansion more nearly equal to those obtained in cylinders.

EDITORIAL COMMENT

WITH the announcement of the successful meeting of the two headings of the Simplon tunnel, on February 24, attention may well be directed toward the changes and modifications which the opening of the new route is expected to effect. Naturally, the thrifty Swiss are looking for many important opportunities for the further exploitation of that supply of natural scenery which constitutes so large a proportion of their stock in trade, and the tourist traffic and the development of hotel sites will form no small portion of the return which the mountain republic will receive for the outlay which it has made upon the enterprise.

The great importance of the tunnel, however, lies in the effect which it will have upon railway connections between Italy and the sea, and these will bear a brief examination. With the opening of the Simplon-Jura connection to the Italian railway system there will be available for purposes of commerce five different methods of reaching Italy by land. By the Semmering Pass Vienna is connected with Venice, while Innsbruck and Verona are united by the railway over the Brenner Pass. The St. Gothard route, with its famous tunnel, runs from Milan to Lucerne, while the Mont Cenis railway and tunnel enable direct connection to be made from Turin to France without passing through Switzerland at all. The extension of the Simplon-Jura railway up the Rhone valley, through the Simplon tunnel to Iselle and Domo d'Ossola, gives direct communication from Geneva and Lausanne to Novara and Genoa.

The Semmering and the Brenner routes give ample communication with Austria; the Mont Cenis line is wholly French, while the St. Gothard serves its original purpose by enabling Italy to reach the North Sea by way of Germany, Holland, and Belgium, and the ports of Hamburg, Amsterdam, and Antwerp. At the time the Simplon project was launched there was insufficient attention given to its effects in France, but it has become evident that the advantages of the lower altitude—2,300 feet as against 3,800 for the St. Gothard, and 4,200 for the Mont Cenis—as well as the reduction in distance, will divert the traffic to Calais and to Ostend, and undoubtedly affect the commerce of Marseilles. By the existing connections the distance from Milan to Calais is 712 miles by the St. Gothard, while it will be only a few miles less with the present connections, but the time will be materially reduced by reason of the lower grades. When, however, the Vallorbes tunnel is pierced, the distance from Milan to Paris by way of Lausanne and Pontarlier will be reduced from 556 miles to 518 miles, and it will be possible to reduce the time between the two cities to 14 hours.

Another route, by way of Lons-le-Saunier and the Col de la Faucille, has been proposed, but the advantages which it offers are partially offset by by the fact that it would require the piercing of several comparatively long tunnels. It has also been suggested that a direct connection across France to the Atlantic coast might be arranged

by combining existing railways, a suitable port being that of St. Nazaire, at the mouth of the Loire, this giving a great advantage over the North Sea ports of Hamburg, Bremen, and Antwerp for Transatlantic commerce.

There is no doubt that Genoa will be greatly benefited by the opening of the new line in any case, while the whole of the Jura-Simplon connections in Switzerland, including Geneva, Lausanne and the Rhone valley towns will also be the gainers. Through traffic will find the new route preferable to that over the St. Gothard, and if the proper connecting lines are built France should gain more by the traffic to the North Sea and the Atlantic than she loses at Marseilles. The experience with the past shows that there has been a sufficient increase in business to keep old and new routes busy, and there is every reason to believe that neither the Mont Cenis nor the St. Gothard will lose much, since the new route will operate to create new traffic in addition to the old.

* * *

DR. BELL, whose leading article in this issue is full of most interesting suggestion, well says in his introduction that "the subject of civilization is human development—all the rest is accidence." Modern achievements are valuable only by "their effect upon the growth of humankind, and the evolution of a sounder society." But he shows that in the case of an achievement so apparently technical even as the distribution of electricity, the direct influence upon environment, opportunity, and social conditions is most immediate and of vast possibility. Similar results, in varying degree, attend almost all the great applications of science which make up the work of the engineer. It would seem that the man who undertakes to keep generally informed as to the work and progress of the world should have some kind of a chart of the main points of engineering accomplishment—what is being done, at least, though not necessarily *how* it is done. Yet which of the periodicals professing to keep its readers in touch with all human affairs attemps this?

The past few weeks have been unusually full of engineering event or achievement of a kind which is widely interesting because it is the foundation for broad developments in industry, commerce, finance, and politics. But of the two principal illustrated monthly reviews, the one devoted primarily to periodical literature selects, from all the engineering field, a minor application of electric traction to omnibuses on common roads—fully covered, by the way, in the Continental papers and in THE ENGINEERING MAGAZINE nearly two years ago—while the one professedly devoted primarily to action finds, in the whole range of engineering, nothing at all to note.

However, it is not very many years since the complete education of a gentleman included scarcely more than the classics. Perhaps after another generation the idea may prevail that the well-informed man of affairs should have put before him some kind of an intelligent summing-up of the physical progress of civilization—not in the manner of the kindergarten, nor of the melodrama, but sanely and plainly.

* * *

ONE or two large engineering undertakings have been much discussed lately, and have served to fix attention upon the vast expenditures involved in such work—expenditures more than justified, in well-considered ventures, by the proportionate wealth-earning or wealth-saving power of the completed work, or by its contributory influence in the general development of industry and commerce and the betterment of social conditions.

The aggregate of the larger engineering propositions now actively under way in this country is, however,

almost overwhelming. Limiting the list to Greater New York alone (that is, to the subway, tunnel, bridge, terminal, and water-supply work certain to be completed within a very few years), the total is close to $500,000,000 —figures that would have staggered the world not long ago. And yet the undertakings are launched, and financed, and carried through to success with far greater ease than attended the execution of works one-tenth the size, within the easy memory of men still in active life. We seem to deal with hundreds of millions as easily almost as we handled single millions twenty-five years ago. The underlying causes and the future bearings of this vast prosperity will be most strikingly pointed out in a forthcoming series of articles in this Magazine. For the present, there is the welcome certainty of years of profit and expansion in the engineering industries and in all lines of manufacture turning out engineering material.

* * *

THE extent to which labor is saved and the time of mechanical operations is shortened by the use of modern appliances may be well illustrated by an example taken from recent work at the New York Navy Yard. Since the article on shipyard cranes was written by Lieut. Shultz, published elsewhere in this issue, the floating crane Hercules was called upon to place the heavy guns on board the battle-ship Indiana, which has been undergoing repairs and overhauling. This work was accomplished in the short space of four and a quarter hours. When it is realized that there were four guns, each weighing 75 tons, the length of a gun being 39 feet and the breech-diameter four feet, the efficiency and labor-saving value of the machine will be appreciated better.

* * *

IT is significant (and to us very welcome) to note that "Production Engineering" is now receiving definite recognition as a distinct branch of applied science, and that several of the technical schools are giving it a larger or smaller place in their engineering courses—not always with the adequacy of conception or the distinctness of formulation which it deserves, but at least with an acknowledgment of the importance of certain of its elements to the successful practice of modern engineering.

The situation, in our view, is not unlike that in which electrical engineering was placed some twenty years ago. Many conservative institutions, if it had then been suggested to them to create a new department in the electrical field, would have replied that they were already covering the subject in their course in physics. In a sense, the reply would have been correct; they were teaching the science as it had long been understood; but it had just entered into a vast new field of application, demanding new methods of attack, and the schools of applied science which took the initiative in establishing a chair of electrical engineering soon found it requisite to expand the course into a department—and by no means the least important in their curriculum.

Something similar, apparently, is likely to occur in the elevation of production engineering into a separate, clearly defined technical course. The difficulties in its way are great; the pressure on the time of the college year is already heavy, and the financial resources of almost all the universities are overtaxed as it is. But the former point could doubtless be met by a definite specialization in the new course during the student's last year; and as to the latter—the subject is certainly one which, by its absolute business common sense, should appeal, as worthy of endowment, to some suceessful man of affairs who has himself seen the profitable results of this most practical of all applied sciences.

REVIEW OF THE ENGINEERING PRESS.
"THE WORLD IS ITS FIELD"

BRITISH COAL SUPPLIES.

THE EXTENT, AVAILABLE RESOURCES, AND RATE OF EXHAUSTION OF THE COAL FIELDS OF THE UNITED KINGDOM.

Report of the Royal Commission.

SEVERAL years ago a Royal Commission was appointed to inquire into the broad question of the condition and probable duration of British coal supplies. This commission, composed of a number of eminent engineers and economists, has made interim reports from time to time, and now the final report has been made public. In considering this important subject the report is divided into a number of headings, treating of the resources of the British coal fields, and their probable duration; possible economies which may be effected; the effect of the export of coal on British consumers and on the navy; and the maintenance, under existing conditions, of the competitive power of British mining industries with the coal fields of other countries.

Accepting 4,000 feet as the limit of practicable depth in working, and taking one foot as the minimum working thickness, it is estimated that the available quantity of coal in the proved coal fields of Great Britain is about one hundred thousand million tons. Nearly 80 per cent. of this is in seams of two feet thick and upwards, and 91 per cent. is in seams of 18 inches thick and upwards.

In addition to the coal within 4,000 feet of the surface, there is a considerable quantity in the lower levels, this being estimated at more than five thousand million tons, but whether or not this is recoverable depends upon the depth at which it may be found practicable to carry on mining operations. There are a number of collieries, notably in Belgium, where seams are being worked at depths in excess of 3,000 feet, but, so far as is known, there are no seams at present worked at depths exceeding 4,000 feet, and there are no insuperable engineering or mechanical difficulties indicated in connection with such deeper workings. On the Continent the limit of working has been placed at 1,500 metres, or about 4,900 feet, so that the limits set by the commission at 4,000 feet is entirely within the judgment of present practice.

So far as the thickness of seams is concerned, the thicker seams are naturally worked first, but during the year 1900 it is estimated that nearly 18 per cent. of the total output of the United Kingdom was obtained from seams of less than 3 feet thick. The introduction of coal cutting machines may be expected to enable seams to be worked successfully which could not otherwise be utilized, and this is a point of especial importance.

The important question of the probable duration of British coal resources depends chiefly upon the rate of the annual output. At the present time the annual output is 230 million tons, and for the past thirty years the average increase has been 2½ per cent. per annum, while the increase in exports, including bunkers, has been 4½ per cent. per annum. It is believed, however, that the rate of increase has about reached the maximum, and that the rate of increase of output may soon be expected to become slower, followed by a period of stationary output, and then by a gradual decline.

The introduction of machinery, both for coal cutting and for handling, has been very fully considered by the commission, and there appears to be no doubt that such appliances are to be recommended, due regard being had to the conditions of each case under consideration.

The opinions of the commission with regard to the manufacture of coke, and the use of briquettes is of especial interest.

"In the industry of the manufacture of coke by far the most important step in recent times has been the introduction of the bye-product recovery ovens. The prejudice against coke made in these ovens lasted long, but is being gradually overcome. It is found that by careful quenching, the difficulty as to colour can be to a large extent obviated, while chemical analysis and practical experience show little or no difference between the coke made in these and other forms of oven. That there is still a large margin for the further introduction of these recovery ovens is shown by the fact that in 1902 only 10 per cent. of the total output of coke was obtained from them.

"The production of coke as it is extensively carried on in this country, without full utilisation of the volatile products, is condemned by all the witnesses. In the best modern practice these products are either burnt in flues round the ovens, or are separated by cooling into liquids and gases, the latter of which are used for heating the ovens themselves. The surplus gas can be used for the production of power under steam boilers, or with greater advantage in gas engines. Coke oven gas is a rich gas, approximating to illuminating, and far richer than producer gas.

"The importance of the extended adoption of coking cannot be exaggerated. It is one of the methods by which small coal can be rendered marketable, and in some districts it has reduced the waste by furnishing the collieries with an outlet for the small coal, without which outlet it is doubtful whether they could have been carried on.

"Hitherto the manufacture of briquettes has been mainly confined to South Wales, where the small coal made in the screening and in the transit of the best steam coal, is mixed with 8 to 10 per cent. of pitch and converted into briquettes. Large quantities of similar small steam coal are exported to the Continent for the same purpose. Of the value of these briquettes as a fuel there is no doubt, and they are extensively purchased by the Royal Navy as a reserve stock in hot climates, where they are said to deteriorate less than Welsh coal. In England and Scotland briquettes are seldom made, probably because there is a good market for small coal. There is, however, every reason to anticipate that in the future they will be more largely used for steam and domestic purposes, and there appears to be a good field for the discovery of a suitable binding material—pitch, which is the chief binder used at present, being rather too smoky for domestic purposes, and also high in price.

"The evidence points to the conclusion that a suitable briquette plant, if well managed, should pay in connection with a colliery; at present the briquette factories in this country are mostly situated at, or near, docks. Suggestions have been made that partial distillation, in addition to washing and cleaning, would give a much wider choice of material for the manufacture of first-class briquettes, and that coal and oil might be used in combination so as to form briquettes of good calorific value out of inferior coal."

That coal is wastefully used at the present time is a matter concerning which there is little difference of opinion. From the most reliable statistics at present available it is gathered that the consumption of coal for the year 1903 was 167 million tons, and of this great consumption it has been computed that there is a possible saving of 40 to 60 million tons, or about one-fourth.

The principal source of economy in the use of coal appears to be in the conversion to gas, and the utilization in internal-combustion motors, as well as in the saving and utilization of the gas now produced in metallurgical operations. Since much more gas is produced by blast furnaces than can be advantageously used in the works, it has been suggested that the electrical distribution of power from such centres would enable a large amount of energy to be replaced which is at present produced by the direct consumption of coal.

So far as liquid fuel is concerned, it is

believed that, while it is of much value and service for special purposes, that it cannot be considered as a serious means of replacing coal to any extent. There is no real substitute at present in sight, and coal is the only reliable source of power, these other sources providing only some slight relief in the demand for coal.

A material saving in the use of coal may be anticipated by the establishment of central stations for the generation and production of power in bulk.

"Hitherto, nearly all such stations in this country have been worked by steam power, and although there are a few gas-engine stations, it is stated that they do not compare favourably with steam-engine stations in practice. It is admitted, however, that gas engines ought to, and will in future, displace the reciprocating steam engine for driving dynamos for large power.

"Dr. Hopkinson has made an interesting comparison between steam plants and gas plants for central power stations. After giving detailed figures he sums up in this way:—'Hence it appears that such a central station as has been described, if equipped with gas plant, will involve a capital outlay approximately the same as with steam plant, and that the fuel consumption, if worked at full load continuously, will be reduced in the proportion of 100 to 83, and if with a load factor of 25 per cent., in the proportion of 100 to 35. These figures only represent the actual saving in fuel. The economy in the money cost of fuel is much greater, owing to the fact that coal can be used in the producers, which can be supplied at less cost than coal for use in the steam boilers, proportionately to its calorific value, and also to the fact that the recovery of the ammonia may be taken as a direct saving in fuel cost, equal, in the case of coal used in the producers worth 7s. per ton, to a saving of 4s. 6d. per ton at the present price of ammonium sulphate.'"

An important matter is the supply of suitable coal for the use of the navy, certain qualities, such as calorific efficiency, smokelessness, cleanness, hardness, free burning, minimum of ash and clinker, and freedom from caking or trouble in stoking being demanded.

"Experiments are constantly being made with different coals, with mixtures of coals or coal and oil, and with various appliances, and, generally speaking, the Admiralty are trying in every way to extend their sources of supply, but so far, it is said, no fuel has been found equal to Welsh coal for naval purposes. In this connection, however, it is interesting to note the increasing and economic use in the mercantile marine of other and cheaper grades of coal and of small or mixed coals, which has been rendered possible by the employment of improved boilers and furnaces.

"In recent years many experiments have been made in the Navy with oil fuel, and the results are said to be promising, but the uncertainty of obtaining an adequate and regular supply must always be a serious objection to the substitution on a large scale of oil fuel for coal. There seems, however, reason to believe that in the future oil fuel will be used for auxiliary purposes in men-of-war, and internal combustion engines working with volatile oils have been successfully introduced for the propulsion of small vessels. There is also the proposal to apply gas producers and internal combustion engines on board ship, and these being smokeless will tend, if successful, to lessen the use of high-class Welsh steam coal. Whatever be the outcome of these experiments, the evidence shows that in the opinion of the advisers of the Admiralty it is necessary, under present conditions, to coal the ships of the Navy with the best steam coal."

Broadly, the report leaves matters in a condition which is hardly reassuring as to the future, but not alarming as to the present. There is enough coal for the present generation and for those which are to follow it immediately. As for those who are to come three or four hundred years after us, but little can be said. They must solve their own problems for themselves, and certainly we cannot settle them at this date. Possibly they will look back upon these deliberations with an amused complacency, in the knowledge of other sources of energy which shall have then been discovered, and in any case they must be left to work out their own salvation with the means and appliances at their command, regardless of what may have been done by their predecessors.

THE ECONOMY OF SUPERHEATED STEAM.

DATA AND RESULTS OF THE LATEST TESTS OF COMPOUND SUPERHEATED-STEAM ENGINES IN GERMANY.

M. F. Gutermuth—Verein Deutscher Ingenieure.

IT has now become generally recognized that the only way in which the steam engine can compete in thermal efficiency with the internal-combustion engine is by so modifying the operative fluid that it shall practically become a permanent gas, within the limits of temperature change employed, and thus prevent the losses which follow from internal condensation. In other words, a fluid which is used at or near its critical point cannot be expected to enable as high an efficiency to be secured as is possible with one in which no change of state can be produced. In the case of the gas engine the problem is comparatively simple, but with the steam engine the fact that the gaseous steam may be more or less converted into the liquid state during the working cycle, introduces sources of loss which have been the study of engineers ever since the days of Watt.

At the present time the best method of preventing the losses due to cylinder condensation is generally accepted to be the superheating of the steam. Multiple-expansion has been carried to its limit for the initial pressures which have been found practicable, and about all that can be expected has been realized from that expedient. Steam jacketing is but a palliative, and hence it has been found that the next, and apparently the only means to improve steam economy is to convert the steam into what is practically a gas, by giving it such a degree of heat beyond the temperature due to its pressure that no conversion to the liquid state shall be possible during the time it is undergoing expansion in the cylinders of the engine. The latest experiments which have been made upon engines using superheated steam have been those upon machines of the so-called semi-portable type, built by Wolf, of Magdeburg, and from a very complete analysis of such tests, made by Professer Gutermuth, of Darmstadt, and published in the *Zeitschrift des Vereines Deutscher Ingenieure*, we make some abstract, as being of very general interest and importance.

Two different types of semi-portable engine are described by Professor Gutermuth, the difference being mainly in the arrangement of the cylinders, one being a tandem and the other a cross-compound, while comparative trials were also made on a simple engine of similar general construction.

The boiler used with the Wolf engines is a modified form of locomotive boiler, having a cylindrical corrugated firebox, short straight tubes, and a long extension smoke box in which the superheater is placed. The superheater is formed of a helix, or rather a series of helices, the whole forming an endless coiled pipe, the steam from the boiler passing through the successive coils and then directly to the engine, which latter is mounted on top of the boiler shell in the manner usual with portable and semi-portable engines.

The engine had cylinders of 285.9 mm. and 540.9 mm. diameter, and 570 mm. stroke, giving a ratio of 3.65 to 1, the power being 200 h.p. at 155 revolutions per minute. The cranks were set opposite each other, and both cylinders were fitted with piston valves, regulation being effected by a shaft governor connected to the valve of the high-pressure cylinder.

The boiler had 48.55 square metres heating surface, and 1.18 metres grate surface, giving a ratio of 41 to 1, while the superheater had 32 square metres heating surface. Five series of tests were made, each ranging from four to five hours duration and with various degrees of superheating, the performances of the engine and the boiler being very fully tabulated and analyzed in the paper by Professor Gutermuth. To these tabulated results the reader must be referred for details, but the results, so far as steam consumption may be given here. With initial steam pressure of 11.8 atmospheres, or 173.4 pounds per square inch, and a vacuum of 90 per cent., the steam consumption per horse-power-hour was as follows: at 78° C. superheat, 4.91 kilogrammes (10.8 pounds); at 122° C. superheat, 4.71 kilogrammes (10.35 pounds); and

at 142° C. superheat, 4.625 kilogrammes (10.17 pounds). The coal consumption per horse-power hour for these same tests was 1.38, 1.36, and 1.36 pounds respectively, the coal containing 7.11 per cent. of ash, and giving, by analysis and the *Verband* formula, a calorific value of 13,650 B.T.U.

This is certainly an excellent showing, especially for an engine of such a moderate size, the thermal efficiency working out at a little over 19 per cent., which is approaching quite closely to that of some of the smaller gas engines. Doubtless a part of the good performance is to be found in the manner in which the superheat steam passed directly to the high-pressure cylinder from the superheater, there being practically no opportunity for condensation losses. Professor Gutermuth analyzes the performance, both by the comparison of the combined indicator diagrams with the theoretical card, and also by the temperature-entropy analysis, and the whole paper forms an excellent study of the conversion of heat into mechanical energy.

In the case of the tandem compound engine, of the same makers, the dimensions were smaller, the cylinders being of 160 and 200 mm. diameter respectively, giving a ratio of 3.57 to 1, developing from 50 to 60 horse power. In this case, besides the initial superheating of the steam, there was a reheating of the steam between the two cylinders, and notwithstanding the smaller size of the machine the performance was somewhat better. With 87° C. superheat, upon an initial pressure of 12 atmospheres, or 176 pounds, and a vacuum of 90 per cent., the steam consumption per horse-power-hour was 4.36 kilogrammes, or only 9.6 pounds!

These tests show the distinct economy which may be obtained by superheating, but they also show that there is a limit beyond which little or no gain is secured. Thus the performance at 142° superheat was but a trifle better than at 122°. In the case of the tandem compound engine, with interheater the performance was better at 87° superheat than with the larger engine at 142°. It is probable that superheating is of value in so far as it counteracts cylinder condensation, but that so soon as the temperature which will prevent internal condensation is passed there is little or no gain in economy by increase in temperature.

THE ELASTICITY OF REINFORCED CONCRETE.

A DISCUSSION OF THE MANNER IN WHICH METALLIC REINFORCEMENTS ENABLE CONCRETE MEMBERS TO SUSTAIN GREAT ELONGATION.

A. Considère—Comptes Rendus.

IT is well known that ordinary concrete, while possessing great resistance to compressive stresses, yields to much smaller forces acting in tension. For this reason concrete has, until recently, been employed in compression only, and not until the methods of imbedding reinforcing elements of metal were introduced, has it been considered advisable to permit concrete structures to be subjected in any part to tensile stresses. Since the general introduction of reinforced concrete it has been sought to derive accurate methods for computing the resistance of various members, notably of beams of various design, and for this purpose it has been found necessary to determine the strength and elasticity of the material. Some of the most interesting investigations in this direction have been made in France by M. Considère, and as a result of his experiments he has announced that concrete, properly reinforced by having metallic members imbedded in it, is capable of being submitted to far greater elongations than concrete not reinforced, and that in his tests the concrete was not cracked and that test pieces of plain concrete taken from the beams after extraordinary elongation showed no material reduction either in crushing or tensile resistance over pieces which had not been subjected to the stretching test. These conclusions, while adopted by some engineers, have not been generally accepted, and subsequent experiments by other investigators have been cited to controvert the position taken by M. Considère. As the subject is an important one in connection with a rapidly growing department of structural work, M. Considère has undertaken a new series of experiments to sus-

tain his position, and in a paper contributed to a recent issue of *Comptes Rendus,* and presented before the French Academy, he gives an account of these investigations.

In his own words, the position which M. Considère has hitherto held, as a result of his experiments, is thus stated:

When pieces of reinforced concrete are subjected to direct tension or to flexure, the fibres under tension behave in the same manner as if they were not reinforced, so long as the tension and the elongation do not exceed those which non-reinforced concrete can support without rupture. If the test is continued still further, reinforced concrete, properly prepared, can sustain much greater elongations, during which the tension remains sensibly constant, and, consequently, its modulus of elasticity is zero.

The fact that this position has been adversely criticised by both German and American engineers has led M. Considère to have a new series of experiments conducted, and in order to eliminate the personal element from these new investigations they were caused to be conducted under the direction of MM. Mesnager and Mercier, in the laboratory of the Ecole des Ponts et Chaussées.

The tests were made upon beams 15 cm. wide and 20 cm. deep, and 3 metres long, these being made by M. Grouselle, a manufacturer of reinforced concrete structures, according to his usual method, without any special precautions. The concrete was composed of 400 kilogrammes of Portland cement, marked E. Candlot & Cie, to 400 litres of sand and 800 litres of calcareous gravel. The quantity of water used represented 9.6 per cent. of the weight of the dry materials.

The reinforcement consisted of two rods of mild steel of 16 mm. diameter, and three rods of 12 mm. diameter, placed close to the side subjected to the greatest extension. One of these beams was protected from the air by being covered with bagging and boards, which were wetted by a hose continuously during the first month, and regularly every two days afterwards, while the other was immersed in water after one day for setting, and kept under water thereafter.

These beams, which were made on May 27, 28, 1904, were subjected to bending tests on November 21 and December 22 following. The tests were made by supporting the beam at points 5 cm. from the ends and applying hydraulic pressure at two points 7 cm. apart at the middle, in such a manner as to give a constant bending moment without shearing action. The extension on the face subjected to tension was observed by two microscopes placed 1.02 metres apart, while the compression on the upper face was measured by two appliances of the Manet-Rabut type, placed 0.5 metre apart.

In accordance with the pre-arranged plan, the test of the first beam was stopped when the extreme elongation of the fibres of the concrete was 0.625 mm., and for the second beam with an elongation of 1.3 mm. In neither case could any fissure be perceived by the microscopes upon examination of the smooth surface of neat cement, which had been applied to the face of the beams under tension in order to facilitate the examination.

After the tests the lower portion of the beams, including the steel reinforcement, was carefully removed, and the part immediately above cut by a saw and subjected to separate test. These portions, it must be observed, had been subjected to elongations ranging from 0.22 to 0.55 mm. for the first beam, and 0.56 to 1.07 mm. for the second, while it is well known that non-reinforced concrete breaks before its elongation reaches from 0.10 to 0.20 mm. Now, if these portions, cut out from between the reinforcement and the part of the beam which had not been subjected to the same strain, had possessed only the same elastic limit as non-reinforced concrete, they should have been expected to fall to pieces as soon as they were deprived of support. On the contrary, they showed no traces of cracks or weakening, and in the testing machine these pieces gave excellent results.

These experiments, therefore, have demonstrated that properly prepared members of reinforced concrete can be subjected without injury to elongations far greater than those which would cause rupture in non-reinforced pieces, and that after such extensions the concrete possesses a tensile strength practically equal to that which it previously possessed.

M. Considère admits that members of reinforced concrete frequently show fine cracks and fissures, but he explains these in an entirely different manner than has been used by his critics. When concrete

is exposed to dry air after mixing, it experiences a marked contraction during the first few days, when its resistance is yet low. If this contraction is impeded by the metallic reinforcement, the strength of the concrete is not sufficient to compress the metal along with it, and at this period there are formed very fine fissures which subsequently become enlarged when the member is subjected to mechanical tension. If, however, the concrete is kept constantly wet for a sufficient length of time, this contraction does not occur, and there is no tendency to produce fissures before the material has acquired the strength and elasticity to prevent them. There is no doubt that the concrete tends to contract when it is no longer kept moist, but the strength is then quite sufficient, notwithstanding the opposition of the metallic reinforcement, and the cracking does not take place.

It is undoubtedly desirable to provide sufficient cross section to the reinforcing metal to meet the entire tensile stress, but nevertheless it is important to understand the laws which control the deformations of the material. If these are not known, it is impossible to determine the deformations of the entire structure, or the distribution of stresses which follows, neither can the position of the neutral axis be determined in members subjected to flexure, nor the pressures produced in the fibres under compression.

PRINCIPLES OF BLAST-FURNACE PRACTICE.

A REVIEW OF THE FUNDAMENTAL PRINCIPLES INVOLVED IN THE MANUFACTURE OF IRON FROM THE ORE IN THE BLAST FURNACE.

Edward A. Uehling—Franklin Institute.

THERE is probably no one industry of more importance to the engineering world than the manufacture of iron, and yet it is one which has grown up through generations of empirical practice to which the application of scientific methods has only recently been made. In a paper recently presented before the mining and metallurgical section of the Franklin Institute, Mr. Edward A. Uehling, himself identified with important improvements in blast furnace practice, examines the fundamental principles involved in the making of iron in the blast furnace, and shows how the correct use of scientific methods affects the commercial and practical results.

Discussing first the raw materials Mr. Uehling shows the desirability of maintaining uniformity in the ore, this being always possible by making a mixture of various ores in proper proportions. Neither a very lean nor a very rich one is desirable, and a regular mixture of low-grade ores is to be preferred to an irregular mixture of much higher average grade. The chemical elements must be selected with a view of producing the required iron, but the physical conditions are less controllable. Refractory ores should be finer than those which are more easily reducible, but it will not do to have the ore too fine, or too great a resistance will be offered to the blast and too much dust carried over into the flues.

Mr. Uehling discusses the flux, the slag, and the fuel at length, showing the importance of producing a proper slag, in order that the sulphur may be absorbed and the silicon content regulated. Coke is at present used almost entirely as fuel, and its composition should be carefully considered as having an important influence upon the product. Sulphur is objectionable, while the ash should be low in alumina and high in silicon, since most of the silicon in the iron comes from the ash of the coke.

In considering the important element of the blast itself, Mr. Uehling calls attention to the fact that the air is the largest, cheapest, and most neglected constituent of the raw materials involved in the process of smelting. Here the question of uniformity is again most important, although this fact has not been fully realized until recently. The quantity should be regular, the blast being so controlled as to supply a constant volume, as can readily be done by maintaining proper speed of the blowing engines taking into account the barometric pressure and the relative humidity of the external atmosphere from which the sup-

ply is drawn. The hot-blast system enables the temperature of the air supplied to be controlled, and although opinions differ as to the actual temperature which it is desirable should be maintained, there is practically no difference of opinion as to the importance of having a controllable regular temperature.

The much discussed question of the drying of the blast is very fully examined by Mr. Uehling; and his own investigations of the subject are especially interesting in view of what has since been accomplished by Mr. Gayley.

"There are few, if any, furnace managers that are not aware of the fact that humidity is an important element in the blast. Very few, however, have taken the pains and the trouble to determine what this factor amounts to quantitatively. During the period referred to above, the author made hygrometric determinations and was surprised to find that the quantity of water carried into the furnace by the blast during the humid summer months amounted to tons of water in twenty-four hours. It is not uncommon for the air to contain 8 grains of moisture per cubic foot. At this degree of humidity a blast furnace taking 35,000 cubic feet of air a minute will, therefore, receive $35{,}000 \times 8 \div 7{,}000 = 40$ pounds of water vapor per minute, or 2,400 pounds per hour, or over 28 net tons in twenty-four hours. Since that time (1886) the author has persistently advocated the economical importance of removing this moisture from the blast, and the process of refrigeration as the best method for removing it.

"Knowing the amount of moisture going into the furnace with the blast, it is easy to figure the fuel required to neutralize its chilling effect. Making this calculation we find that one pound of moisture requires in round numbers 1.3 pounds of carbon to be burned at the tuyeres to replace the heat absorbed by the decomposition of the water vapor. This, in itself, amounts to a very considerable quantity of fuel during the summer months, yet it is less than 25 per cent. of the actual fuel saved, as demonstrated at the Isabella Furnaces by Mr. Gayley's desiccating plant.

"The strictest attention is paid by every furnace manager to guard against water getting into the furnace through leaky tuyeres or cooling plates, yet absolutely no regard is given to the contamination of the blast by avoidable moisture. Innumerable steam leaks are often allowed to exist in the engine-room, nearly all of the steam from which is carried into the furnace without any idea of the fuel necessary to overcome this extra moisture. So long as these leaks do not become positively annoying to the engineer, they are rarely attended to. One instance in the writer's experience may be permissible to illustrate. At the plant in mind the blowing engines and pumps were in charge of the master mechanic of the works, over which the furnace manager had no authority. Repeated requests to repair the leaky joints were ignored. Hygrometric tests of the blast showed that it contained between 5 to 7 grains of moisture per cubic foot above the outside atmosphere. Calculations based on this moisture content laid before the general manager brought the necessary pressure upon the master mechanic. The steam pipes were overhauled. The effect was an immediate reduction in the fuel consumption of 150 to 200 pounds per ton of iron. There is no doubt in the author's mind that similar fuel economies might be obtained at many of the existing plants.

"In the author's estimation desiccation of the blast is a step in advance, second in importance only to the hot blast, and that it will be as generally and perhaps even more promptly adopted."

Although the reduction of iron from the ore is essentially a chemical operation, very little is definitely known about the chemical reactions which take place in the blast furnace. We know the nature and composition of the raw material charge at the top, and we can ascertain the character and properties of the product tapped out at the bottom, as well as the composition of the escaping gases. These are indications of what is actually going on inside of the furnace, but only indications. Mr. Uehling discusses the reducing action of the carbon monoxide produced by the burning of the carbon, and also the phenomenon of carbon impregnation, with its consequences of hanging of stock; slippingg, both top and bottom; and scaffolding; and holds that many of these operative dis-

turbances may be greatly reduced if not entirely eliminated by careful preparation and charging, uniform blowing, desiccation, and regular heating of the blast.

The important question of the utilization of furnace gases is given especial consideration by Mr. Uehling, and he refers to his own early computations upon the blast furnace as a power plant, in which he showed that, under conditions of best average fuel consumption, viz., 2,000 pounds of coke per ton of iron, and proper treatment and utilization of the gas, there would be a surplus of at least 800 horse-power per ton of iron produced per hour. Or, in other words, a blast furnace of a daily capacity of 250 tons, or, in round numbers, 10 tons per hour, should have a surplus of gas over and above all furnace requirements, sufficient to generate 8,000 horse-power in any of the available types of large gas engines. Other investigators, notably Mr. B. H. Thwaite, who is the pioneer in the field of direct utilization of blast-furnace gas, have come to similar conclusions.

"Since publishing the above calculations, the author has had opportunity to investigate the blast-furnace gases at a number of the large iron and steel plants, and has found that his figures were very conservative; that from 1,000 to 1,200 horse-power is nearer the actual surplus power that should be available.

"In view of these facts, and the practically more weighty fact, that on the continent of Europe, especially in Germany, there is scarcely a furnace plant where not from several to many thousand horse-power are generated by blast-furnace gas direct, is it not strange that, with one laudable exception, nothing at all has been done to save the enormous waste now going on because of the irrational application of the blast-furnace gas?

"From 45 per cent. to 50 per cent. of the heat value of the fuel used in the process of smelting in the blast furnace is contained in the escaping gases, of which 35 per cent. should be sufficient to heat the blast and produce the power to run the furnace and all its mechanical accessories. In spite of this enormous theoretically demonstrable surplus heat energy, the fact remains that, at the majority of the blast-furnace plants, hundreds of tons of coal are burned annually to assist the gas in generating the necessary steam for the power required, and it is the exception rather than the rule that the desired blast temperature can be regularly obtained from the stoves, notwithstanding the fact that both stoves and boilers have from time to time been increased both in size and number. The sole reason of this deplorable condition is due to the fact that the uncleaned gas cannot be efficiently utilized. It is just as irrational to burn the impure gas as it would be to attempt to burn coal mixed with all the slate and rock that is dug and raised with it from the mine."

RAILWAY REPAIR-SHOP MANAGEMENT.

THE ADVANTAGES OF OPERATING RAILROAD REPAIR SHOPS ON THE MONTHLY APPROPRIATION PLAN.

Charles Streicher—New York Railroad Club.

AMONG the various systems of works management which have been advocated by the able engineers and superintendents who have given attention to the subject but few have considered the subject of the repair shop. In nearly every case the existing systems have been planned for the manufacturer, and when the special shop is considered it is generally attempted to modify some of the plans for what may be termed shops of original production, to fit, as nearly as may be, the special case under consideration.

Nearly all railroads now purchase their locomotives and other rolling stock, but practically all roads maintain repair shops, not because of any idea that they can do the work more economically than others, but because it is absolutely essential to have control of the work and to be able to handle emergency jobs in accordance with their own knowledge of the requirements. At the same time it is altogether possible to conduct such repair work so that it shall be done at minimum cost as well as in minimum time, and hence any discussion of the

methods of management of such shops is of importance and interest. In a paper recently presented before the New York Railroad Club Mr. Charles Streicher discusses the cost of making repairs on rolling stock, and shows that the absence of proper system may lead to unnecessarily high average charges per locomotive and car.

In order to reduce these repair charges, Mr. Streicher advocates the introduction of the monthly appropriation plan, and maintains that by this method millions can be saved and the equipment at the same time. By the monthly appropriation plan is meant the practice of appropriating a fixed amount of money each month for each division for the purpose of paying for the maintenance of equipment, labor and material in the shops, yards, inspection, points with the clear understanding that pay rolls and purchases of material must not exceed the amounts appropriated, except in cases of unavoidable emergencies, and then only by furnishing satisfactory explanation.

"This method differs from the more general practice of running up unlimited pay rolls and for purchase of material not needed for immediate consumption by putting a positive and reasonable prohibitive stop to it.

"This method, instead of having the general officers guessing what the monthly expenditures and demand on the treasury will be, enables them to make positive financial arrangements.

"This method, instead of opening up wide avenues for extravagance, also expenditures not immediately necessary, making the fellow who spends the most think he is doing the most work, is a direct mandate, and also appeals to all concerned, for economy, offering those alive to the opportunities the chance to produce 'maximum results with minimum cost.'

"This method, instead of throttling individuality, develops inventive, executive and managing ability, educates men and cultivates the habit of making the most of adverse-looking circumstances and opportunities, if not hampered by red tape.

"To formulate a plan, system or method, and to introduce and execute same successfully are two vastly different propositions.

"The introduction of the method is generally disliked. All kinds of adverse criticism and predictions are made. If, however, theh executive officers, general foremen and foremen are of the right kind, practical men capable of taking the wheel in their own hand, willing and able to demonstrate with tact, firmness and personal efforts the feasibility, in short, are competent to educate the men up to the method and gain thereby their co-operation, all is well. The successful execution depends largely on appropriations, based on recorded facts, coupled with reasonable expectations. They must be made with due consideration of shop facilities, locality and circumstances, rarely found alike on different divisions."

As a base for determining the appropriations it is necessary to have the cost statements, including labor and material, covering different classes of engines and cars, summarized and averaged as to parts and units of equipment. These statements must then be distributed in parts to all officials in their respective departments, down to the position of assistant foremen, gang bosses, inspectors, including shop accountants and time clerks, receiving fixed daily or monthly compensations. There must then be made a monthly distribution of comparative average cost sheets, per unit of equipment, covering the entire system. The division officials should make out monthly reports, expressing their experience under the method, backed up by figures and facts, with practical propositions as to how equipment expenses may be reduced and material saved, these to include suggestions as to the possible limitations of the amounts to be appropriated, taking into account the working conditions to be met.

Mr. Streicher considers it absolutely necessary, for the successful execution of the scheme, that the locomotive and car shops should be operated under the piece-work system, both for skilled and unskilled labor. As he says: "It is simply ridiculous to assume that after contracting for locomotives, cars, and implements for so much apiece, and the purchase of material by measurable quantities in pounds, tons, feet, gallons, etc., that we should permit the practice of maintaining and repairing the same things by the unmeasurable, bottomless, go-as-you-please day methods."

The appropriations of each division

should be made by the general executive officers in lump sums, in consultation with the superintendent of motive power. It is a mistake, possibly fatal in consequences, to bind division master mechanics and master car builders down to itemized appropriations, since thereby the personal responsibility of division officers is logically removed from them. In view of the nature of the offices they hold and the duties connected therewith, general executive officers cannot be familiar with the actual detail condition of the motive power and rolling equipment of the entire system. This absolutely essential personal knowledge of existing conditions can only be had by the man on the spot, and therein his resources lie. If he is given a reasonable appropriation and material allowance he may well be expected to conduct the work according to conditions, following the rule of give and take, and using his appropriation, within his limitations, according to circumstances.

The limitations of the appropriation system will soon be reached by those railroad officials who introduce the method with the sole desire of making a personal record, regardless of the conditions of the equipment; but if, on the other hand, their guiding motive is to obtain the best service for the least money they will continually find new ways of accomplishing their purpose.

If success is to be attained care must be taken to avoid certain causes of failure which Mr. Streicher enumerates. Thus it is a mistake to attempt to drive the employees, instead of persuading them to aid in the work. Again, if at first appropriations are exceeded, the matter must be examined impartially, to give the parties responsible a chance to redeem themselves, after the source of the trouble has been discovered, since all success must come from the individual efforts of the men who are ultimately responsible. It is a mistake to cut the appropriations too low, or to hamper division mechanics and master car builders with interference; rather they should be given full swing coupled with corresponding responsibility as regards results.

"Within the last ten years we have witnessed the construction of the most powerful locomotives, doing the work of two or three of the older types. Steel cars and cars with steel underframes, having carrying capacity from 80,000 to 100,000 pounds, are replacing wooden equipment. On their construction is based the expectation of reducing cost of repairs at least 25 per cent. Modern shops, with all conceivable facilities to handle material economically, have been built. Lathes, planers, boring mills, drill presses, punches, morticers, gainers, etc., are in operation, capable of handling double the previous output. Self-hardening tool steel has shattered all cutting records, lineal as well as diametrical. Pneumatic, electric, hydrostatic machinery and tools unknown ten years ago are common now.

"Consolidation of small roads, with larger systems, is the order of the day, on which the hopes of reducing maintenance of equipment expenses are based."

With all the efforts which have been made to centralize administration and to detail and systematize the work, the proportion of maintenance and equipment expense to total operating expense has from 1897 down to 1903 increased from 16.352 per cent. to 19.133 per cent., while during the same period conducting transportation has been reduced from 57.92 to 55.89 per cent., and general expense has been lowered from 4.756 to 3.789 per cent. This is attributed by Mr. Streicher to the fact that the individuality of the men who are responsible has been neglected, and it is to stimulate and develop this individual factor that he recommends the introduction of the monthly appropriation system.

While the argument of Mr. Streicher is excellent, it is possible that there is another reason why the repair account has increased while other departments have lowered their expenses, namely, the present tendency to drive the equipment to the fullest possible capacity, regardless of wear and tear, on the theory that an appliance should be worn out in service before sufficient time has elapsed for it to become obsolete. The ultimate economy of this principle is well established, and it is entirely reasonable that it should be accompanied with an increase in the proportional repair account along with a decrease in the other departments whose performance it may have helped to improve.

THE DEVELOPMENT OF THE LARGE GAS ENGINE.

PROGRESS IN THE DESIGN AND CONSTRUCTION OF POWERFUL INTERNAL-COMBUSTION ENGINES IN GERMANY.

Prof. E. Meyer—Stahl und Eisen.

THERE has been no more interesting feature in mechanical engineering in recent years than the increase in magnitude and power of the internal-combustion motor. Writing in the pages of this Magazine in 1898, Mr. Dugald Clerk, one of the pioneers in this important field, discussed the large gas engine from the viewpoint of that date, and made the prediction that in the future "there will be gas engines as powerful as any steam engine ever built." At that time the largest gas engine in existence was of 200 horse power, and this consisted really of two 100 horse-power engines coupled, and in view of this enormous machine, Mr. Clerk refers back with amusement to the fact that in 1879 a 16 horse-power Crossley engine was admired as the "King of Gas Engines," being the greatest in existence then and for several years after. Mr. Clerk also made an interesting prediction, which has been more than verified, namely: "It is evident that the large engines of ten years hence will differ as much from the large gas engine of to-day (1898) as does the latter from the engine of 1886 or 1887. There can be little doubt that in ten years, gas engines of 1,000 h.p. will be as common as engines of 100 h.p. are now."

At the meeting of the Verein Deutscher Eisenhüttenleute held recently in Düsseldorf, a paper on large gas engines was presented by Dr. Eugen Meyer, and published in recent issues of *Stahl und Eisen*, describing some of the recent developments in large gas-engine construction on the Continent, and it is seen that the prediction of Mr Clerk has been fulfilled in a much shorter period than the ten years which he named. In his paper Dr. Meyer illustrates and describes engines of 1,000 to 2,000 horse power, representing such establishments as Oechelhäuser, Otto, Körting, Krupp, Cockerill, and others, the limit in size set by Mr. Clerk being exceeded as much as the time has been shortened.

The increase in the power of gas engines has been brought about by several circumstances. The early machines were intended to be operated by illuminating gas, and the cost of this fuel naturally limited the use of such motors to small powers, where convenience and operative conditions were of greater importance than the actual cost of the power. The thermal efficiency of these small motors was much higher than that of steam engines, but the cost of the fuel overbalanced the heat economy. With the introduction of producer gas, and especially since the utilization of the waste gases of the blast furnace has been developed, the question of the supply of low cost fuel has been solved, and there are no limits to the size of units except those imposed by constructive questions.

The earlier large engines were built upon the four-cycle system, and of this class was the large Cockerill engine which attracted so much attention at the Paris exposition of 1900. Messrs. Körting increased the power of their machines at first by employing two opposing four-cycle cylinders, but this plan was later followed by the use of two tandem cylinders, this being important as demonstrating the practicability of using packed stuffing boxes in gas engine construction. With this arrangement came also the use of water-cooled pistons, both rod and piston being included in the water circulation.

In examining the leading types of large gas engines, Professor Meyer takes up first the Oechelhäuser engine, and then considers the two-cycle machine of Körting, giving also some examples of the double-acting tandem four-cycle engine. The Oechelhaüser engine, as is well known, has two opposing pistons in a single cylinder, these being connected to the same crank shaft so as to approach and separate every revolution. A pump is used to give the charge a preliminary compression as well as to supply a scavenging discharge of air, the two pistons covering and uncovering the ports in the cylinder at the proper times, the charge being ignited electrically. Engines of this type have been built with a single cylinder

up to 1,500 horse power, many large Oechelhaüser engines being in use in German iron works for supplying the blast to the furnaces, using the waste gases from the blast furnaces as fuel.

The Körting two-cycle machine is designed on the general lines of a horizontal steam engine, with closed cylinder, stuffing boxes, and power strokes on each side of the piston. The two-cycle action is secured by the addition of a separate compression pump, this pump having mechanically-operated valves, similar to the Rider expansion valve for steam engines, the governor controlling the gas charge by regulating the admission to the pump cylinder.

The various attempts to make a successful two-cycle gas engine have resulted simply in making some substitute for the suction and compression stroke in the Beaude-Rochas cycle, so that it has been generally found simpler in practice to couple two four-cycle cylinders rather than to attempt to make a two-cycle machine. The latest designs of large gas engines have been made with two four-cycle cylinders arranged in tandem, and in some instances these have had double-acting cylinders, involving closed cylinders, stuffing-boxes, and water-cooled pistons and rods. Engines of this type as large as 2,000 horse power have been built by the Deutz works, with cylinders of 1,100 mm. bore and 1,300 mm. stroke (43.3 in. by 51.2 in.) and similar machines have been built by other well-known makers.

The design of such large gas engines involves something more than the mere enlargement of details of smaller machines. Noteworthy in all of the examples illustrated by Professor Meyer are the arrangements for cooling, not only the cylinders and pistons being water-cooled, but the mushroom valves themselves, being sufficiently large, are also fitted with water circulation, as are also the chambers in which they are fitted. The general arrangement of the water circulation is a matter to which especial attention should be given, the cold water being first directed about the actual explosion chamber, where the greatest amount of heat is generated and from which it must be quickly absorbed, after which the water is passed to those portions less exposed to the highest temperature.

Professor Meyer calls attention to the importance of providing rounded corners and fillets in the interior portions of these large cylinders, especially at the points where the ports enter, since cracks are apt to form at such points under the great temperature variations if sharp angles and corners are left. The working parts should also be so arranged as to permit free expansion and contraction, and in general, the precautions which have repeatedly been urged as necessary for steam engines operating with highly superheated steam, demand even greater attention in the case of the large gas engine.

The performance of these large gas engines may be gathered from some figures which are given by Professor Meyer. Thus a 500 h. p. Oechelhäuser engine, using coke-oven gas and driving a blowing cylinder, required 1,930 calories per indicated horse-power-hour, including the power required to drive the air pump, and taking the metric horse-power-hour as equal to 632.5 calories, this gives a thermal efficiency of 32.7 per cent. on the indicated power. Allowing for the frictional and other resistances, the heat consumption is given as 2,340 calories per brake horse power, corresponding to an efficiency of about 27 per cent. Similar data for a Nürnberg engine of 1,200 h.p., using blast-furnace gas, showed a heat consumption of 2,260 calories per brake horse-power-hour, or a thermal efficiency of 28 per cent. In general the four-cycle engine is somewhat more efficient than the two cycle, since the negative work in the first case is only about 6 per cent. of the indicated power, while the use of a separate air pump raises the negative work for the two cycle machine to between 10 and 11 per cent., with a corresponding decrease in efficiency.

The prediction made by Mr. Clerk in 1898 has thus been more than fulfilled, and internal-combustion engines of more than 1,000 horse power are already common and have been repeatedly exceeded. With the increasing use of gases from blast furnaces and from coke ovens together with the improvements in gas producers which shall enable them to use freely the lowest grades of fuel, the employment of the vapor of water as an intermediary agent in the conversion of heat into mechanical energy will be rendered unnecessary, except in a limited number of special cases.

POWER FOR ELECTRIC RAILWAYS.

CONDITIONS GOVERNING THE PROPORTIONS AND ARRANGEMENT OF THE STEAM POWER PLANT FOR ELECTRIC TRACTION OPERATION.

E. P. Roberts—Ohio Interurban Railway Association.

IN making the preliminary plans and estimates for a steam power plant it has usually been sufficient of the designing engineer to know the general character of the work to be done in order to enable him to make the proper arrangements. For a manufacturing establishment such as a textile factory, for instance, he knows that uniformity of speed regulation is most essential, and given the number of spindles, looms, or other machines, he is able to decide definitely the size of engines and volume of steam to be supplied. Again, for a rolling mill the irregular demands for power are well understood, and suitable devices included in the regulating mechanism to enable the attendants to throw on all the power necessary in the instant of emergency.

With the introduction of electric power for urban and interurban traction, however, a new set of operative conditions were introduced, and it has required all the observation and experience of able and practical engineers to determine the best methods of arranging the plant to meet the requirements. In a paper recently presented before the Ohio Interurban Railway Association by Mr. E. P. Roberts the question of steam power for electric railroads is very fully discussed, and some abstract of the paper is here given.

"To decide what prime mover is best for a specific case, considering type, number of units and size of each, all the factors affecting the case must be considered, and, generally speaking, in the following order:

"First—Predetermination of the operating conditions.

"Second—Estimate of first cost.

"Third—Estimate of operating expenses, including financial charges.

"Fourth—Comparative reliability, depreciation and repair account, and other matters which are largely questions of judgment.

"Fifth—Combination of all the above, considered for each type of power plant, and a comparison of the results.

"This necessitates a decision as to the location of the track, and the curves and grades most economically desirable, and the predetermination includes the following:

"A certain location of the road is taken as the standard for comparison, being generally that which will give excellent, though not necessarily the greatest, accessibility on the part of the public, and having such grades and curves as a general knowledge of the proposition indicates would be good practice. The size of cars and number of trains necessary to handle the anticipated passenger travel is decided, and train schedules and train sheets are prepared which show the schedule time between the terminal points, based on a stated average schedule speed in the cities and towns, and a stated average speed while the car is in motion in the country, with deduction from the latter on account of country shops, thereby obtaining the schedule speed in the country. The train sheet shows the trains in service at any moment and the location of such trains. The size of motors necessary to handle a car or train of the assured weight and speed is then calculated."

The importance of thus making a preliminary layout of the whole system appears in the fact that a study of such a scheme often shows where useful modifications may be made, while there is yet time. Mr. Roberts gives several examples to show the difference in the cost of operating roads which have been carefully planned and those which have not had the same consideration, indicating very clearly the money value of careful and competent preliminary work.

"Having predetermined the average maximum power required from the engine, or engines, when operating on regular schedule, and also for special days, a tentative decision is made as to the number of units and the size of each, based on capacity.

"The condition of operation of engines furnishing power to an interurban electric road is, except when storage batteries are used, one of rapid and excessive fluctu-

ations of load, usually ranging from 25 per cent. to 125 per cent. of the rated capacity of the engine, and often from 0 per cent. to 150 per cent., and sometimes momentarily up to 200 per cent.

"For any engine supplied with steam at a definite pressure and quality and with a definite vacuum, there is a definite load at which it will operate at its greatest economy. Increasing the steam pressure, or superheating the steam, or increasing the vacuum will increase the maximum obtainable horse-power and, generally speaking and within limitations, the efficiency of the engine as a converter of heat energy into mechanical energy, but, considering the increased energy required by the engine auxiliaries, it will not necessarily increase the heat-energy efficiency, considered as a whole, and, even more important, it may even decrease the 'dollar efficiency.' The latter efficiency includes first cost and operating expense, and it is upon this efficiency, considering the entire road, that either dividends or assessments are declared."

By studying curves obtained from the operation of existing plants, some useful lessons may be drawn for comparison in planning new works. Thus it is made evident that a comparison of engine performance based upon the water consumption of the respective engines when operating at their rated capacity, it not reliable for a decision when the engines are to be operated under variable loads.

In like manner comparisons based on indicated horse power do not give the same results as those based on boiler horse power. Engines for interurban electric railways are obliged to operate with loads varying from the mere friction load to 100 per cent. overload, but the average load is practically always below the normal rating. The engine should therefore be designed so as to carry excess loads with safety, and also to give a maximum steam economy at a point below that which is ordinarily considered normal rating. The valve gear should permit the steam to follow a large percentage of the stroke when necessary, and the pipes and connections arranged so as to produce the minimum drop in steam pressure, while the cylinder should be no larger than absolutely necessary.

It is very desirable that fuller information should be available concerning the performance of steam engines at various loads. Nearly all builders have reliable data from numerous tests as to the performances of their engines at normal rating, but the results at fractional loads, often more important in their effects upon the economy of the plant, are not so easily obtainable. A comparison of several engines at various proportional loads brings this out very clearly, and the point is one to which engine builders may well give interested and practical attention. Instead of limiting themselves to reports of tests showing the excellent performances of their engines at normal power, they would find a distinct commercial advantage in publishing reports of reliable and disinterested tests of these same machines at several loads above and below the normal, showing the range of variation which the customer who has a variable load to meet might expect.

Mr. Roberts has some interesting remarks to make about the comparative performances of steam turbines and reciprocating engines, and he believes that the better results reported where turbines have been installed are due to the fact that the turbine plants have been of a higher grade than the engine plants with which they have been compared.

"Turbine plants generally have superheated steam, frequently at a higher pressure than the average reciprocating engine, and also with higher vacuum, and they do obtain better efficiency from the standpoint of water per kilowatt-hour than the majority of the engine plants in interurban power houses. But it does not necessarily follow that reciprocating engine plants could not have been so designed as to have obtained equally high efficiency, nor does it follow that the plant which is most efficient from the standpoint of fuel is the most economical, everything considered. I believe in the steam turbine, but do not consider that it has the field to itself, but rather that each case must be considered on its own merits.

"Many comparisons which have been published are misleading. For example: Some comparisons are made on the basis of rated load, which have been shown to be inaccurate when applied to a variable load; others

are based on pounds of steam per kilowatt-hour taken by the turbine or the engine, and without making allowance for the additional heat energy required to obtain the higher vacuum for the turbine. In this connection it should be noted that the efficiency of the turbine is materially increased by an increased vacuum, whereas this is much less the case for an engine built on commercial lines. For the turbine it is wise to obtain high vacuum, but the cost must not be overlooked.

"The steam for the turbine is also usually superheated, and, if the comparison is based on a difference in pounds of steam, it is evident that consideration should be given to the additional heat units in the steam and the cost of supplying such additional heat energy. When considering fuel economy the proper basis of comparison is the per cent. of heat energy transformed into mechanical energy delivered by the mechanism, including the amount of energy required for the auxiliaries."

Mr. Roberts's paper is a valuable contribution to power-plant engineering, and adds one more to the many evidences that the engineer is becoming more and more of a business man, according to the definition that an engineer is a man who can do for one dollar what any fool can do for two dollars.

EXPLOSIONS IN AIR COMPRESSORS.

CAUSES OF IGNITIONS AND EXPLOSIONS IN THE DISCHARGE PIPES AND RECEIVERS OF AIR COMPRESSORS.

Alex. M. Gow—Engineering News.

THE subject of explosions in connection with the use of compressed air has, until recently, received much more attention in Europe than in America, and in fact, after a discussion and review in these columns of some explosions which occurred in Germany a few years ago, the very fact that such accidents could take place was vigorously contested by an able engineer, experienced in compressed-air machinery. We now have a very full discussion of experiences in America with explosions of this sort, and from a paper by Alex. M. Gow in a recent issue of *Engineering News* we abstract some important points.

"Ignitions and explosions in the discharge pipes and receivers of air compressors are by no means uncommon. The increasing use of compressed air at higher and higher pressures, together with the general ignorance on the part of the men in charge of the machines, as to how and why such accidents occur, make it probable that they will continue to occur with greater frequency. For very obvious reasons the manufacturers say as little as possible about the subject to prospective buyers. It cannot be expected that the men in charge at the time of accident will make any report that will reflect upon themselves. So it happens that in but comparatively few cases of these accidents have the results of careful investigation been given to the public at large.

"From an examination of about twenty accidents, of which more or less complete data have been gathered, a clear conception of the causes has been formed, from which may be drawn definite conclusions as to the means of prevention. In a number of the cases examined serious explosions have occurred, resulting in fire and death; in others, simply ignition, or burning out, with no other damage than that to pipe joints and gaskets. One case of a Bessemer blowing engine is reported where the pipes have been red hot on several occasions and been allowed to burn out. In another case the ignition so vitiated the air that was being sent into a mine that men were asphyxiated. The report upon a very serious explosion states that 'the air in the discharge pipe first caught fire and then exploded,' it having been observed before the explosion that the pipe was red hot.

"These accidents are not confined to any one type of compressor, nor are they confined to cases where the terminal gage pressure is unusually high. It is in the discharge pipe and receiver that the trouble occurs, and in most cases the compressor escapes without injury. Rarely, if ever, does the explosion take place immediately

in the cylinder. One case is reported where the cylinder head was blown off, killing the man who was examining the discharge valves, but even in this case the evidence does not prove that the explosion did not originate in the receiver.

"It is perfectly evident that just before such an accident there must be something to burn, in the discharge pipe or receiver, and a temperature sufficiently high to ignite it. Accumulation of combustible matter, together with a terminal temperature at the end of a compression stroke sufficient to start combustion, accounts for the cases of ignition; the presence of a gas or vapor, forming an explosive mixture with the air, with a temperature equal to the burning point of the vapor at the pressure, accounts for the cases of explosion. Where, as is reported in a few cases, ignition has preceded explosion, it is clear that in the first place there was a sufficient temperature to start combustion, and then there was driven off a gas or vapor, and this, mingling with the air in suitable proportions, formed an explosive mixture. We have, then, to inquire as to the origin and nature of the combustible matter and to the causes and conditions that tend to produce excessively high temperature."

The combustible matter, consisting of various accumulations of hydrocarbons, is derived from the lubricants necessarily used in the compressing machinery, while in and around all collieries this is mixed with coal dust drawn in with the air. The lubricant is the principal source of the trouble, however, and hence the first precautions are to be taken as to its character and the quantity used.

The lubricants generally employed are a mixture of soap and water or cylinder oil. Either will produce a carbonaceous deposit, particularly when used in such excess as to permit a quantity to be carried over from the compressor cylinders into the receiver and pipes. Deposits formed from soap and water have been found to ignite at temperatures between 400° and 500°. The greatest trouble, however, is found with explosions, rather than mere ignitions, and these require the formation of a combustible vapor and its mixture with a suitable proportion of air. Since it requires but a low percentage of hydrocarbon vapors to explode in air, and as this percentage diminishes with the temperature, while the explosiveness increases with the pressure, it will be seen that the elements of danger are present in very many cases.

"Now, combustible gases or vapors are evolved from all lubricating oils by heat. The lowest temperature at which they begin to come off is called the 'flash point' of that oil. At a somewhat higher temperature the gas or vapor will ignite; this is called the 'burning point.' The flash point of kerosene is usually below 150° F. Ordinary lubricating oils flash at about 250° F. An average of determinations on 40 samples of heavy oils having average flash point of 360° F. gave average burning point of 398° F.; high flash test cylinder oils, from 500° F. to 560° F., gave burning points of 600° to 630° F. The vapors evolved from any of these oils, at the flash point, or the oils themselves, atomized or sprayed, would form an explosive mixture with the suitable percentage of air. From the above table it is evident that as low as 1 per cent. by volume would form such a mixture. If the oil were mixed with coal dust the temperature at which such a deposit would evolve a vapor would be the flash point of the oil. It follows that none but high flash test oil should be used in the cylinder."

In order that the danger from explosions may be minimized care should be taken both in the design of the apparatus and in its use. The discharge valves and clearance spaces should be so arranged that there may be no small pockets or recesses where oil may accumulate. Even with the greatest care in design and in the most sparing use of lubricant there will be some accumulation of carbonaceous matter while the danger from coal dust drawn in with the air is always present.

So far as the temperatures produced in the compressors are concerned, these depend upon the degree of compression for their origin. The temperatures attained, however, are very materially affected by two elements, one being the temperature at which the air is originally drawn in and the other the effectiveness of the means which are provided for carrying off the heat and preventing its accumulation. Mr.

Gow gives a diagram with curves showing the rise of temperature due to the adiabatic compression of dry air and these show very clearly how the rate of increase in temperature depends upon the initial temperature of the air.

The use of water jacketing, for the cylinder walls and heads, is necessary to prevent the working parts from becoming too hot, but Mr. Gow shows that on large machines the water jacketing of the compressor cannot be depended upon to absorb the heat of compression, since there is too much heat produced for the time and surface available.

"Compression by stages, with inter-cooling, with provision for after-cooling in an emergency, are the surest means by which to avoid dangerously high temperatures in the receiver. The curves show the reduction in terminal temperature that may be attained by inter-cooling to any temperature between stages, and inasmuch as for adiabatic compression, the rise of temperature is proportional to work expended, they also show to what pressure each cylinder should operate in order that each shall do an equal amount of work. Knowing the weight of air compressed per stroke and its specific heat, the curves also give the necessary data from which to calculate the British thermal units to be absorbed by the inter-cooler."

The experiences with air compressors are of especial interest in connection with the results which are well-known in connection with internal-combustion motors. Although the cylinders of gas engines are well jacketed with cold water circulation, and in the larger sizes water cooling is used for the pistons, cylinder heads, and even the valves, it is well understood that the compression cannot be carried to the most advantageous extent because of the danger of preliminary ignition and explosion of the mixed charge of gas and air. In the Banki motor the temperature is kept down by spraying water into the charge, and it is held that one of the advantages of alcohol as a fuel for internal-combustion motors is the presence of sufficient water to aid in keeping down the compression temperature. One of the ingenious features of the Diesel motor lies in the utilization of the heat of compression for the ignition of the charge, and by compressing the air separately, and not injecting the oil until the beginning of the power stroke, very high compressions are employed with safety. Although the cylinder of the Diesel motor is water jacketed the temperatures reached in the cylinder are sufficient to ignite and to burn completely the heaviest oils and petroleum residues, and even coal dust has been successfully burned in these motors, the only difficulty with such powdered fuels being the injurious effect of the non-combustible particles of ash, etc., upon the interior of the cylinder.

Mr. Gow's paper is a valuable contribution to the subject of the design and use of air-compressing machinery, and the recommendations and suggestions which he makes, based upon the past and costly experience of many users of compressors, are worthy of careful study and utilization.

ALTERNATING-STRESS TESTS.

METHODS AND APPARATUS AT THE NATIONAL PHYSICAL LABORATORY FOR DETERMINING THE BEHAVIOUR OF MATERIALS UNDER ALTERNATING STRESSES.

Dr. T. E. Stanton—Engineering.

ENGINEERS are gradually beginning to appreciate the fact that there are other data desirable to be known about materials of construction besides the mere tensile strength. At one time the ultimate resistance to tension was about the only thing which was attempted to be ascertained, and this fact has been attributed, rightly or wrongly, to the preponderating influence of the work of Kirkaldy and his followers. Then it appeared that other things were of importance, and now we have apparatus for making torsion tests, shearing tests, crushing tests, and a variety of other experimental determinations of the resisting properties of the materials used in engineering structures. Among these later researches the study of the effects of vibration and of frequently repeated stresses is being given increased at-

tention, and various special testing machines have been designed for this department of mechanical research. The latest apparatus of this kind is the new machine designed and constructed for use at the National Physical Laboratory, and from a very complete account of this important testing machine by Dr. T. E. Stanton, published in a recent issue of *Engineering* we abstract the following account.

"Experiments on the effect of alternating stresses were first made by Wohler, whose experiments were subsequently repeated by Spangenburg in 1874. Sir Benjamin Baker has also published the results of experiments, made in some cases by simple bending, and in others by Wohler's method, which consisted in the rotation of a bar to the end of which a definite bending moment was applied, and which is obviously the simplest and most easy to carry out. More recently a machine has been constructed, and a most valuable series of experiments made by Reynolds and Smith, in which for the first time direct tension and compression uniformly distributed over the section of the specimens was obtained. The method adopted was that of employing a rotating crank to cause periodic motion of a reciprocating mass by means of a connecting-rod, the specimen under test forming the connection between the reciprocating mass and the cross-head; so that an alternating force was produced in it, depending on the magnitude of the mass and the speed of rotation of the crank. The machine consisted essentially of a single-balanced crank, which operated two reciprocating equal masses in the same vertical plane, to one of which was attached the specimen, whose motion was vertical; the other, whose motion was horizontal, being utilised to keep the kinetic energy of the system, and therefore the speed of rotation, constant.

"As experiments on uniformly distributed stress are undoubtedly of far higher value than those on bending, in which the maximum stresses exist at the surface of the specimen only, and their real values are difficult to determine, it was decided to adopt the method of Professor Osborne Reynolds in the design for the National Physical Laboratory machine, with the modification that four cranks operating four specimens should be employed instead of one. By introducing this modification a machine could be made, the moving parts of which would be perfectly balanced, the speed of rotation practically constant, and which would allow of the comparison of four different qualities of material under exactly the same stress conditions throughout the life of the specimens. The importance of this last condition will be readily understood when the difficulties are considered of obtaining an exact comparison between the resistances of various specimens which have been tested separately, involving as they must the greatest care in speed regulation to obtain the same stresses in each trial. The chief objection to this four-cranked arrangement was that it practically entailed the horizontal motion of the masses, but it was hoped that the consequent frictional effects could be made so small as to be negligible. A further advantage lay in the fact that with the four cranks the method of balancing could be made independent of the ratio of the crank-arm to the connecting-rod, so that a length of crank-arm could be adopted which would enable experiments to be made at considerably lower speeds than those obtained by Reynolds and Smith, which were in no case lower than 1,300 per minute, the experiments of Wohler and Sir Benjamin Baker being made at about 60 revolutions per minute. Further, the results of the high-speed trials, ranging from 2,400 to 1,300 alternations per minute, showed that, for a given range of stress, the life of the specimen depended largely upon the period of the alternation, so that it was considered most desirable to extend the observations to speeds which are more commonly obtained in practice."

The machine is illustrated and described in detail by Dr. Stanton, and it presents many elements of interest. There are two independently-balanced systems on the same crank shaft, each system consisting of two cranks placed at 180 degrees with each other, with the connecting rods, cross-heads, and specimens on opposite sides of the crank shaft. The parts are so arranged that the reciprocating masses are exactly equal and the crank shaft is balanced in itself, while the adjustments of the completed machine included the distribution of

material in the connecting rods so that the centres of percussion should be similarly situated in the connecting rods. The cranks of the second system are placed at right angles to those of the first, so that the kinetic energy of the reciprocating parts shall be approximately constant, thus keeping the fluctuations of speed during a complete revolution as small as possible. Special care has been taken in the provisions for lubrication, and the frictional resistances have been carefully determined, so that corresponding corrections can be made.

As in other forms of testing machines, the appliances for holding the specimens undergoing test have been designed so that there shall be no preliminary stresses created to affect the value of the results. Since the fracture of any one of the test pieces would destroy the balance and possibly wreck the machine it has been necessary to introduce a clutch which comes into action the instant a specimen is fractured. India rubber buffers, with a very small clearance, are also provided, and the contact made with a buffer at the instant of the fracture of a specimen, serves to give an electric warning and enable the time and counter readings to be made. The machine is driven by an electric motor, speeds from 500 to 2,000 revolutions being attainable, with control for any intermediate speed.

THE TANTALUM LAMP.

AN ACCOUNT OF THE NEW INCANDESCENT LAMP OF THE SIEMENS AND HALSKE MANUFACTURING COMPANY.

W. von Bolton and O. Feuerlein—Elektrotechnische Zeitschrift.

IN the early history of the incandescent lamp various attempts were made to use platinum as the material to be raised to incandescence by the heat of the electric current, but these were abandoned when success was reached with the carbon filament. Of late years, however, experimenters have been busy with other materials among which may be noted the Nernst "glower" and the osmium lamp of Dr. Auer von Welsbach. For some time the well known firm of Siemens and Halske has been conducting experimental researches with lamps using tantalum as the incandescent material, and at a recent meeting of the Electrotechnical Society in Berlin a paper was presented by Dr. W. von Bolton and Dr. O. Feuerlein, the two experts who have been conducting the work in the laboratory of the company, giving an account of the results which have been thus far attained. From a report of this important paper in the *Elektrotechnische Zeitschrift* we abstract some of the principal features of this work, which may lead to important changes in incandescent lighting.

Experiments with vanadium, while proving unsuccessful, pointed to other members of the same chemical group, and trials were made with niobium and tantalum. Niobium, although having a higher melting point than vanadium, failed to stand the action of the current, and experiments were therefore made with tantalum. Here the principal difficulty appears to have been the production of coherent metallic tantalum, free from brittleness and capable of being drawn into wire suitable for lamp filaments. This portion of the work was entrusted to Dr. von Bolton, and is described by him. Experiments upon the reduction of tantalum direct from the oxide were only partially successful, but finally it was discovered that by melting the powder in a vacuum the contained gases separated, and a ductile metal was obtained. With the tantalum wire thus produced Dr. Feuerlein proceeded to construct the lamp.

By using wire about 0.3 mm. in diameter it was demonstrated that the melting point of the metal was very high, and also that even under the action of a heavy current there was but a slight tendency to disintegration. The first lamps, made with a loop similar to the ordinary carbon filament, had but a short life, and showed considerable blackening of the bulb. Further experiments, using wires of purer metal and more uniform character, gave continually improving results, and it became evident that the poor performance and high specific resistance which appeared with the early lamps were due to the presence of

impurities, such as niobium and carbides.

After the character and quality of the material was improved it was attempted to determine the proportions for a lamp which should be suitable for standard illuminating values and voltages. Experiments with a trial lamp, having a wire 0.05 mm. in diameter, in a loop 54 mm. long, showed that an illumination of 3.5 Hefner candles was obtained, using 0.58 amperes at 9 volts, a consumption of 1.5 watts per candle power. This indicated that a similar lamp on a 110 volt system would require a filament 650 mm. long, or a little more than two feet, giving 43 Hefner candle power. Since it was desired to keep the lamp within the limits of size already employed for carbon filaments this involved some ingenuity, and Dr. Feuerlein relates in detail the efforts which were made to overcome the constructive difficulties. Among other questions the support of the wire had to be considered, since the metal becomes distinctly softer when heated, and would droop over against the inside of the bulb when the lamp was not held entirely vertical, unless firmly supported. The form finally adopted consists of a double support composed of a short glass rod with a number of radial arms standing out and up from each end, these arms having hooks at the ends, so that the wire could be reeved in and out and up and down, somewhat like the cord of a drum. This form gave a complete support of the wire, and permitted the required length to be arranged within the limited space within the bulb. A lamp of 25 Hefner candle power for a 110 volt circuit, consuming 1.5 watts per candle power, requires a filament 650 mm. in length, weighing 0.022 gramme, and at this rate about 45,000 lamps can be made from a kilogramme of tantalum. Such a lamp has a life of about 1,000 hours, and after a slight increase in efficiency for the first few hours, it maintains its illuminating power well for about 300 hours, after which there is a gradual diminution in efficiency, a 25 candle power lamp falling to 18 to 20 Hefner candles after 1,000 hours, with a consumption of a little more than 2 watts per candle.

An interesting feature of these lamps is the fact that they may be burned out several times without becoming entirely useless. This is due to the fact that a broken end will come in contact with an adjacent portion of the wire and thus re-establish the connection. The lamp will then burn more brightly, because a part of the wire is cut out of the circuit, but this also renders the failure of the remainder a matter of early occurrence.

Since Messrs. Siemens and Halske intend to manufacture these lamps for general use there will be opportunity to test its performance in a practical manner, and there is every possibility that it will take its place among the improved methods of obtaining light from electricity.

MULTIPLE EFFECT EVAPORATION.

THE PRINCIPLES INVOLVED IN THE ECONOMICAL EVAPORATION OF LIQUIDS IN SUCCESSIVE CHAMBERS.

Charles Day—Manchester Association of Engineers.

THE operation of converting a liquid into vapor by means of the heat contained in another vapor is required in many industrial processes. The heating vapor is practically always that of water, while the liquid to be evaporated varies, including sugar juices, chemical solutions, and other substances, the actual evaporation being usually that of the contained water. About the year 1830 the idea of conducting the evaporation in successive chambers was conceived by M. Rillieux, in connection with the evaporation of sugar juices, and from that it has been extended to numerous applications. In a paper recently presented before the Manchester Association of Engineers, Mr. Charles Day discusses such devices and examines the theory upon which their efficiency is based.

"Ordinary multiple effect evaporators consist of two or more vertical cylindrical vessels partaking of the character of surface condensers. Steam, either in the form of exhaust from the engines, or direct from boilers, is usually, though not necessarily, the source of heat by which the evapora-

tion is brought about. The steam thus supplied is taken to the first of the vessels and there surrounds tubes containing the liquor to be evaporated. The pressure inside the tubes is kept lower than the pressure of the steam supplied to the casing around the tubes, consequently the boiling temperature of the liquor inside the tubes is lower than the temperature of the saturated steam outside, with the result that the steam will be condensed to water, which, however, will still be at a higher temperature than the liquor and vapour in the tubes.

"The heat thus given up will practically be the latent heat of the steam, and each pound of steam condensed will evaporate approximately 1 lb. of the water in the tubes, thus generating steam in the tubes. This steam is then conveyed by means of a suitable pipe to the calandria of the second vessel, which also contains tubes through which the liquor to be evaporated passes.

"The pressures in the second vessel and in the tubes are lower than in the first vessel and tubes respectively, hence the steam generated in the tubes of the first vessel now surrounds tubes containing a liquor at a lower temperature; it is therefore condensed, and in condensing evaporates approximately another pound of water. By this means each pound of steam supplied to the apparatus has now evaporated approximately 2 lbs. of water. If, then, the apparatus has three vessels or effects, and the pressure in the third is kept lower than the pressure in the second vessel, the steam generated in this latter can be taken to the third vessel and used to evaporate another pound of water there. This system can be carried on to 4, 5, or 6 effects, or, in fact, to as many effects as the temperature limits will allow."

Devices of this sort are used, not only to concentrate solutions, but also to act in the reverse manner and obtain pure water from solutions containing foreign matter, such as the production of pure water on shipboard from the salt sea water. In any case the important matter of the rate of heat transmission through metallic surfaces enters into the matter. This is a subject which, though much experimented upon, is still vaguely understood, and worthy of further investigation. The law enunciated by Newton, that the rate of transmission of heat is directly proportional to the difference of temperature is no longer accepted as true. Mr. Day refers to the experiments of Hagemann, at Copenhagen, which show that there is an increase in the rate of evaporation per square foot by rapid circulation of the liquid in the tubes, and doubtless this applies not only to evaporators and condensers, but also to steam boilers.

Other experimenters have found that the heat transmission per square foot is three to four times as rapid when the liquid is boiling than otherwise, which fact may explain the greatly improved output from boilers when very hot feed water is supplied to them. Possibly the advantage of live-steam feed-heaters on board ship may be largely due to this action.

Mr. Day examines the action of a Yaryan six-effect evaporator tracing the course of the liquor to be evaporated and the steam by which the evaporation is caused.

"When used for the distillation of water the impure water is drawn from the circulating water which has passed through the condenser, and which has thus been somewhat heated. It is then pumped through the first heater, then forward through the second heater, whence it passes through heating tubes in each of the six evaporating vessels of effects. By the time it has passed through the last set of heating tubes, which is contained in the first, or high temperature effect, or vessel, its temperature will not be much below the temperature of the steam supplied to that effect.

"The water formed by the condensation of the steam supplied to the first effect is usually returned direct to the boiler; thus the boiler is fed with pure distilled water at a high temperature, consequently a high evaporation per pound of coal should result and be well maintained. The steam formed in the tnbes of the first effect, together with the water, pass to a separator; there the steam is separated from the water and is led to the shell of the second effect, whilst the water passes into the tubes of this effect. The pressure in the shell of this effect practically corresponds with the pressure in the tubes of the first effect, but

the pressure in the tubes of the second effect is several pounds lower, hence as the water entering the tubes is at the higher temperature of the previous effect there is immediate and spontaneous evaporation of some of the water, and this causes a lowering of the temperature of the remainder, which reduction of temperature permits of heat being transmitted through the tubes from the steam on the other side causing evaporation of a further quantity of water and the condensation of the steam outside of the tubes.

"Again the mixed water and steam pass to the separator, and the separated steam is then led to the shell of the next effect, and the water to its tubes, but as the water produced by the condensation of the steam supplied to the shell of the second effect is not wanted for boiler feeding, it is drained into the shell of the third effect, and there imparts some of its heat to the water in the tubes. Spontaneous evaporation also takes place here, owing to the water entering a vessel in which the boiling temperature of water is lower than the temperature of the incoming water.

This cycle of operations is repeated in succeeding effects until the last one is reached. From here the water drained from the second, third, fourth, and fifth effects, together with the water of condensation formed on its own tubes, is drained to the second heater, whence it passes to the condenser. The steam from the last separator passes through the safes to the first heater, where some of it is condensed, the final condensation taking place in the surface condenser, where not only does this condensation take place, but the water so formed is, along with the water drawn from the previous shells, finally cooled by the circulating water in the condenser."

Mr. Day goes at length into the computations of the output of a six-effect water distiller, showing that the production of distilled water per pound of coal is 49.2 pounds.

FUEL ECONOMY IN STEAM-POWER PLANTS.

METHODS OF SECURING COMMERCIAL ECONOMY IN THE GENERATION OF POWER FOR ELECTRIC LIGHTING AND TRACTION STATIONS.

W. H. Booth and J. B. C. Kershaw—Institution of Electrical Engineers.

IN all power stations it is the part of good management to produce the required results in the most economical manner, and since the fuel charges constitute about one-half of the total power cost it is to a reduction in fuel consumption that most managers look to effect economies. In a paper recently presented before the Institution of Electrical Engineers, Messrs. W. H. Booth and John B. C. Kershaw discuss the economical operation of electric generating stations, and an abstract of this extensive discussion is of interest.

As in other departments of work, the best efficiency in the power plant cannot be attained unless uniformity in working is secured, and this is practically impossible in either electric lighting or traction stations. The load can be equalized by the use of an accumulator battery, and this method is adopted in a number of cases, but the construction of such batteries is yet so far from being perfected that their adoption is yet a matter for independent investigation, and the authors of the paper under consideration proceeds to discuss the methods of obtaining the best economy independently of any such equalizing apparatus.

Considering only a steam-power station, the subject of economy is divided into a number of heads, including feed water, fuel, boilers and furnaces, steam, waste gases, and draught.

So far as feed water is concerned, it is now fully admitted that it is impossible to obtain the best results unless the water is properly purified and heated before it is passed into the boilers.

No general panacea can be considered, and the water should be properly analyzed in each case to enable the proper remedy to be ascertained, and subsequent analyses made at intervals to determine whether any changes in the nature of the supply have occurred. If chemical methods of softening are employed the purified water should

be examined at intervals, since there is a frequent tendency to overdo the matter, and a proper check should be independently applied. Oil and grease should be separated from the water by the employment of suitable apparatus, intelligently employed, and whenever surface condensation is employed and condensed steam is returned to the boilers, or an open heater is used, an effective oil separator should form a portion of the equipment. A thin layer of scale is advantageous rather than otherwise to the boilers, since it prevents pitting and corrosion, but grease is always objectionable as well as productive of loss.

It has always been considered advantageous to heat the feed water to a point as nearly as possible to the boiling temperature, but there is a further gain secured by the use of live steam to raise the temperature of the feed water still higher than 212° F.

The advantages of using live steam for feed-water heating have been questioned, but there appears to be ample evidence that an economy may be secured by this method if it is properly done. The heat of the live steam is retained in the feed water and thus returned to the boiler, and the advantages of the higher temperature far exceed the slight loss of heat which occurs by condensation and radiation. Various theories have been advanced to account for the marked improvement in efficiency produced by live-steam heating of the feed-water, but none of these has been found wholly satisfactory, but the facts appear to be well substantiated.

A most important question is the proper adaptation of the furnace to the fuel to be burned, and in many places expensive fuel is used because it is asserted that steam cannot be kept up or that smoke is produced, when, as a matter of fact, the cheaper fuels could easily be burned in properly designed furnaces.

Boilers may be divided into three general types; the large shell type; the large water-tube type; and the small water-tube type. All three have their applications, the first being adapted for long-continued steady work, and the latter forms for less uniform demands, the last being especially suited for the peaks of loads of short duration, owing to its capacity for heavy forcing.

A marked source of loss in water-tube boilers is that of air leaks, although the loss from air infiltration has only been fairly recognized in late years. In this respect the internally-fired shell boiler has the advantage, although this is partially offset by other disadvantages. Both through cracks and directly through the brick walls of a water-tube boiler the air can be demonstrated to enter, and it is well said that glazed brick might often be better employed to case in boilers than to decorate engine rooms. It is only necessary to investigate the walls of an ordinary bricked in boiler with a lighted candle to demonstrate the suction of air through the solid walls, while the leakage through cracks is very great.

The authors are not altogether favorable to mechanical stokers, considering them unequal to the prevention of the smoke evil. It is admitted that mechanical stokers have the ability to raise steam with cheaper coal than is demanded by hand firing, besides effecting an economy in the reduction of the stoking staff. At the same time they will not be an economy unless their hoppers are filled mechanically and they ought to be in charge of a skilled mechanic to look to upkeep and maintenance, and not be expected to run with unskilled attention.

The real object of the power plant is to generate power through the medium of steam, and the production of the steam is the object of burning fuel under boilers. The best plant is that which produces the best steam to the best advantage, and this means that it should really be steam which is produced and not a mixture of steam and hot water. The fact that steam begins to lose heat as soon as it leaves the boiler renders it very necessary to protect it as much as possible against sources of loss. The best method of providing that the steam shall be saturated with heat and be at its maximum density per cubic foot for its pressure when delivered to the cylinder is to have it moderately superheated.

The questions of waste gases and of chimney draught are examined at length in the paper, and in conclusion the authors emphasise the fact that the best results can be attained only if scientific methods of control are employed in relation to feed water, fuel, waste gases, and draught.

THE ENGINEERING INDEX

THE KEYSTONE
IN THE ARCH OF APPLIED SCIENCE

The following pages form a **descriptive** index to the important articles of permanent value published currently in about two hundred of the leading engineering journals of the world—in English, French, German, Dutch, Italian, and Spanish, together with the published transactions of important engineering societies in the principal countries. It will be observed that each index note gives the following essential information about every publication:

(1) The title of each article,
(2) The name of its author,
(3) A descriptive abstract,
(4) Its length in words,
(5) Where published,
(6) When published,

(7) *We supply the articles themselves, if desired.*

The Index is conveniently classified into the larger divisions of engineering science, to the end that the busy engineer, superintendent or works manager may quickly turn to what concerns himself and his special branches of work. By this means it is possible within a few minutes' time each month to learn promptly of every important article, published anywhere in the world, upon the subjects claiming one's special interest.

The full text of every article referred to in the Index, together with all illustrations, can usually be supplied by us. See the "Explanatory Note" at the end, where also the full titles of the principal journals indexed are given.

DIVISIONS OF THE ENGINEERING INDEX.

CIVIL ENGINEERING 129
ELECTRICAL ENGINEERING 134
INDUSTRIAL ECONOMY 140
MARINE AND NAVAL ENGINEERING..... 141
MECHANICAL ENGINEERING 142
MINING AND METALLURGY 149
RAILWAY ENGINEERING 154
STREET AND ELECTRIC RAILWAYS..... 156

CIVIL ENGINEERING

BRIDGES.

Arches.

A Three-Hinged Concrete Steel Arch. L. A. Keith. Illustrated description of a recent construction in Mansfield, O., with account of test made of model. 1800 w. Eng Rec—Feb. 18, 1905. No. 67847.

The Computation of Arches and Suspension Bridges (Calcul des Ponts en Arc et des Ponts Suspendus). A. Considère. A mathematical examination of the stresses in arches, and their relation to similarly proportioned suspension bridges. 1800 w. Comptes Rendus—Jan. 23, 1905. No. 67919 D.

The World's Largest Concrete-Steel Arch Bridge: The Gruenwald Bridge at Munich. Gives general illustrated description and dimensions of the design of arch ribs, foundations and piers, roadway and approaches, &c. 3500 w. Eng News —Feb. 23, 1905. No. 67887.

Bridge Floors.

Concrete Floors for Railway Bridges. Illustrates and describes examples of solid floors of reinforced concrete, as used by

We supply copies of these articles. See page 159.

different railways. 900 w. Eng News—Feb. 16, 1905. No. 67805.

Cantilever.

The Moline Bridge. Illustrates and describes a riveted steel-truss through structure about 710 ft. long between centers of abutment seats, and a height of 35 ft. above the water. There are four spans, with three river piers. The bridge is somewhat remarkable on account of the proportions and arrangements of the trusses. 3000 w. Eng Rec—Feb. 11, 1905. No. 67768.

Drawings.

Filing and Indexing Tracings of Railroad Bridges. Explains a system adopted in the office of the bridge engineer of the Erie R. R. Co., New York. Ills. 2000 w. Eng Rec—Feb. 18, 1905. No. 67851.

Erection.

Bridge Launching. B. J. Forrest. A short paper on this method of erection of steel bridges. 1000 w. Can Soc of Civ Engrs—Dec. 22, 1904. No. 68001 D.

Failure.

The Suspension Bridge Failure at Charleston, West Virginia. Addison M. Scott. An illustrated account of the fall of an old suspension highway bridge, describing its construction, the place of failure, condition, &c., and giving brief history. 2000 w. Eng News—Feb. 2, 1905. No. 67629.

Missouri River.

Missouri River Bridge of the Omaha Bridge & Terminal Railway Company. Brief outline of the history of this bridge, with illustrated description of the new structure. 1000 w. R R Gaz—Vol. XXXVIII, No. 8. No. 68023.

Reconstruction.

The Replacement of Members of a Railway Truss Bridge (Streben Auswechslung mit einem Zugstangen Systeme an einer Eisenbahn-Gitterbrücke). Julius Novak. Describing the operation of replacing the struts and tie rods of an old bridge, including experimental methods of measuring existing stresses. 3500 w. 1 plate. Zeitschr d Oesterr Ing u Arch Ver—Jan. 13, 1905. No. 67930 D.

Stresses.

The Computation of Stresses in the Blackwell's Island Bridge. R. C. Strachan. Read before the Brooklyn Engrs.' Club. A description of the stress analysis, with editorial describing the novel features of the bridge, giving points in the stress calculation. 4800 w. Eng News—Feb. 16, 1905. No. 67808.

Suspension.

A Rational Form of Stiffened Suspension Bridge. Continued discussion of paper by Gustav Lindenthal. 3000 w. Pro Am Soc of Civ Engrs—Feb., 1905. No. 68047 E.

The Bonhomme Suspension Bridge over the Blavet (Pont Suspendu du Bonhomme sur le Blavet). G. Leinekugel Le-Cocq. Illustrated description of highway suspension bridge of 160 metres span, near Lorient, France, with details of construction and erection. Serial. Part I. 2000 w. 1 plate. Génie Civil—Feb. 4, 1905. No. 67917 D.

Swing Bridge.

The Troïtsky Bridge at St. Petersburg (Le Pont Troïtsky à Saint Pétersbourg). Describing the manner in which electric power is applied to the operation of the swing span of the new bridge across the Neva. 1200 w. Génie Civil—Jan. 21, 1905. No. 67913 D.

Viaduct.

The New Spans of the Portage Viaduct, Erie R. R. An illustrated description of the third bridge bearing this name, giving details of reconstruction. 2000 w. Eng Rec—Feb. 4, 1905. No. 67652.

Wind Pressure.

Probable Wind Pressure Involved in the Wreck of the High Bridge Over the Mississippi River, on Smith Avenue, St. Paul, Minn., August 20, 1904. Continued discussion of paper by C. A. P. Turner. 2500 w. Pro Am Soc of Civ Engrs—Feb., 1905. No. 68049 E.

CONSTRUCTION.

Building Construction.

The Diamond Bank Building, Pittsburg. Illustrated description of a 12-story, steel-cage office building showing special features in the steel construction for the substructure, and in other details. 2200 w. Eng Rec—Feb. 18, 1905. No. 67846.

The Rapid Construction of the Baltimore-American Building. An illustrated account of the construction of a newspaper building on the site of the great fire within a year from the date of the destruction. 1400 w. Eng Rec—Feb. 18, 1905. No. 67845.

Concrete.

Concrete Construction. Edward Everett. Reviews briefly the history of the early use of concrete, the present use, reinforced concrete, government use of concrete, and gives illustrated description of plans for a concrete warehouse, tests of concrete. &c. 4500 w. Ice & Refrig—Feb., 1905. No. 67650 C.

Waterproofing Concrete Structures. W. H. Finley. Read before the Nat. Assn. of Cement Users. Gives information

showing the need of waterproofing and gives specifications used by the writer with good results. 3000 w. Munic Engng —Feb., 1905. No. 67733 C.

Concrete Blocks.

The Waterproofing of Concrete Blocks. G. B. Kirwan. Read before the Nat Assn. of Cement-Users. Explains why concrete block buildings are damp, and the necessity of waterproofing. 2500 w. Munic Engng—Feb., 1905. No. 67732 C.

Dams.

A Concrete Dam on a Pile Foundation at St. John's Lake, Long Island, New York. An illustrated description of a dam and spillway founded on piles, a cut-off wall of sheet piling being used to prevent percolation through the strata into which the piles are driven. 1500 w. Eng News—Feb. 9, 1905. No. 67704.

A Quickly Erected Reinforced Concrete Dam at Fenelon Falls, Ont. Brief illustrated description of an application of concrete-steel to the construction of dams of moderate height. A dam 194 ft. long and about 10 ft. high was built in 22 ordinary working days. 700 w. Eng News —Feb. 9, 1905. No. 67705.

Grouted Rubble Core Walls for the Weirs of the Delta Barrage, Egypt. Describes the method of core wall construction of the Damietta and Rosetta weirs, built to supplement the old Delta Barrage of the Nile. Account taken from a paper by Major Sir Robert Hanbury Brown, before the Inst. of Civ. Engrs. of Gt. Britain. Ills. 4500 w. Eng News—Feb. 9, 1905. No. 67710.

The Laguna Dam, Yuma Irrigation Project, California. Information concerning a dam about to be built across the Colorado River in Arizona by the U. S. Reclamation Service. Ills. 1200 w. Eng News—Feb. 9, 1905. No. 67709.

Ferry Houses.

A Group of New Ferry Houses. Illustration and plans of the new ferry-houses for the C. R. R. of N. J., the D., L. & W. R. R., and the Erie R. R. at West 22d and 23d Sts., New York City, with brief descriptions. 500 w. R R Gaz—Vol. XXXVIII, No. 5. No. 67626.

Fireproof Buildings.

The Adjusted Fire Losses on the Fireproof Buildings at Baltimore, Md. Report of the Baltimore Convention of the National Board of Fire Underwriters, giving much information in regard to the destruction wrought to fireproof buildings by the Baltimore conflagration. 11400 w. Eng News—Feb. 9, 1905. No. 67706.

Floors.

Test of a New System of Terra-Cotta Floors. Describes a new floor construction made by the National Fireproofing Co., and to be employed throughout the floors of a system of forty warehouses now being built in Pittsburg. An illustrated description of the test made. 2000 w. Eng Rec—Feb. 25, 1905. No. 68042.

Foundations.

Construction of Foundations for the Yonkers Power House of the New York Central R. R. Information concerning foundations involving important coffer-dam and concreting work and special plant. Ills. 1800 w. Eng Rec—Feb. 11, 1905. No. 67771.

Freezing Process.

The Utilization of Artificial Cold (Etude sur l'Emploi du Froid Artificiel). E. Maynard. A discussion of the use of the freezing process for sinking foundations, with especial reference to the construction of canal locks in wet ground. 4500 w. Revue Technique—Jan. 25, 1905. No. 67925 D.

Public Works.

Time Required for the Construction of Large Public Works. Gives records of the Massachusetts Metropolitan waterworks, the New Croton system for the supply of New York City, the Boston subway, the New York Rapid Transit Railroad, the Massachusetts Metropolitan sewerage systems, and the Philadelphia filtration plants. 3000 w. Eng Rec—Feb. 4, 1905. No. 67653.

Race Track.

Planning a Modern Race Track: Belmont Park, at Queens, L. I. Describes the conditions of the topography, and the plan and location of tracks, buildings, &c. Ills. 4500 w. Eng News—Feb. 23, 1905. No. 67890.

Reinforced Concrete.

An Analysis of Concrete-Steel Construction. F. C. Slade. Aims to develop an analysis for the design of concrete-steel structures and to so put the matter in shape that it can be readily understood by the layman. 1200 w. Am Gas Lgt Jour—Feb. 6, 1905. No. 67616.

A Reinforced-Concrete Machine Shop in Philadelphia. Illustrated detailed description of the Hugo Bilgram machine shop, and its construction. 1400 w. Eng Rec—Feb. 4, 1905. No. 67656.

I. Re-enforced Concrete. Robert A. Cummings. II. A Comparison of Reinforced Concrete Formulas. L. D. Cornish. Two short papers discussed together. 3900 w. Pro Engrs' Soc of W Penn—Jan., 1905. No. 67797 D.

Scheme for a Tunnel in Reinforced Concrete (Projet de Tunnel Tubulaire en Béton Armé). Ch. Dantin. Describing a

We supply copies of these articles. See page 159.

system for tube-tunnel lining of light structural skeleton imbedded in concrete. 2000 w. Génie Civil—Jan. 28, 1905. No. 67916 D.

The Extensibility of Reinforced Concrete (Faculté que le Béton Armé Possède de Supporter de Grands Allongements). A. Considère. A review of experimental tests confirming the author's contention as to the great increase in extensibility given to concrete by reinforcement. 1500 w. Comptes Rendus—Jan. 30, 1905. No. 67926 D.

See also Civil Engineering, Bridges.

Roads.

Broken-Stone Roads. Reginald Ryves. A study of the method of constructing roads, the materials used, the effect of water, &c. 2200 w. Engng—Jan. 20, 1905. Serial. 1st part. No. 67543 A.

Data on Roads and Pavements in Iowa. Abstract of the report of the Committee on Roads and Pavements, presented at the meeting of the Iowa Engineering Society. 1800 w. Eng News—Feb. 9, 1905. No. 67707.

Sidewalks.

Practical Work of Constructing Sidewalks. A. T. Gridley. Read before the Nat. Assn. of Cement Users. Gives specifications and considers some of the requisites of good work, materials, methods, &c. 2500 w. Munic Engng—Feb., 1905. No. 67731 C.

Tunnelling.

Compressed-Air Power Plants for the Pennsylvania Railroad Tunnel. A general description of the four Ingersoll-Sergeant plants installed in connection with the tunnelling operations under the North and the East rivers at New York. 1200 w. Compressed Air—Feb., 1905. No. 67978.

The Geological Predictions for the Simplon Tunnel (Ueber die Geologische Voraussicht beim Simplon Tunnel). A comparison of the indications given by the geological commission, with those actually revealed by the boring. 3000 w. Schweiz Bauzeitung—Jan. 28, 1905. No. 67965 B.

MATERIALS OF CONSTRUCTION.

Brick.

The Survival of the Fittest—Brick Tried by Fire and Not Found Wanting. Albert D. Klein. Read before the Nat. Brick Mfrs.' Assn. Remarks on the effect of the Baltimore fire upon brick as a building material. 1800 w. Brick—Feb., 1905. No. 67844.

Cement.

Cement Posts. J. A. Mitchell. Read before the Nat. Assn. of Cement Users. Gives the writer's views of cement posts which are based on an experience of over three years in the manufacture of them. 1500 w. Munic Engng—Feb., 1905. No. 67734 C.

The Dry Mixture of Cement. A. L. Goetzmann. Read before the Nat. Assn. of Cement Users. Considers the dry mixture and the manufacture of concrete blocks under this method, outlining the methods for cement testing and mixing. 3800 w. Munic Engng—Feb., 1905. No. 67730 C.

Cement Kilns.

The Efficiency of Waste Gas Boilers in Connection with Rotary Cement Kilns. A. B. Helbig. An illustrated article aiming to prove that the waste gas boiler solves the fuel problem of the cement mill. 4500 w. Eng News—Feb. 16, 1905. No. 67806.

Clay.

Fire Test and Analysis of Clay. Dr. J. Ohly. Directions for testing to determine the valuation for the making of brick or similar material. 700 w. Min Rept—Feb. 16, 1905. No. 67855.

The Testing of Clay. Prof. Edward Orton, Jr. Read before the Nat. Brick Mfrs.' Assn. Considers chemical testing and empiric testing. 8500 w. Brick—Feb., 1905. No. 67841.

Laboratory.

The Laboratory for the Testing of Road Materials at Columbia University. A. Black. Describes the methods of testing these materials in various laboratories. and the qualities required, and gives tabulated report of tests made at the laboratory of Columbia Univ., and illustrations of machines. 6600 w. Sch of Mines Qr—Jan., 1905. No. 68009 D.

Sand.

Mortar Sand. J. C. Hain. Calls attention to the peculiarities of some sands, comparing their laboratory tests with a standard. 4000 w. Munic Engng—Feb., 1905. No. 67735 C.

Timber.

A Criticism of Some Timber Specifications. Gives quotations from current specifications, with criticisms, and also quotations from rules of a lumber association, with remarks. 5000 w. Eng News—Feb. 23, 1905. No. 67889.

Timber Preservation Experiments in Texas. Abstract of a report on the condition of treated timbers laid in Texas, February, 1902. By Hermann von Schrenk. Published by the Bureau of Forestry. 4500 w. R R Gaz—Vol. XXXVIII, No. 7. No. 67834.

We supply copies of these articles. See page 159.

MEASUREMENT.

Stresses.

Note on the Summation of Stresses in Certain Structures. Carl Hering. States the problem and the results of an investigation, giving illustrations. 1800 w. Pro Engrs' Club of Phila—Jan., 1905. No. 68008 D.

Surveying.

Photographic Methods on the Canadian Topographical Survey. Abstract of a paper by Arthur O. Wheeler. read before the Canadian Congress explaining a very interesting method of surveying. 3000 w. Eng Rec—Feb. 18, 1905. No. 67853.

MUNICIPAL.

New York City.

The Development of the City. An illustrated account of the proposed improvements recommended by the commission appointed by Mayor McClellan. 4000 w. Munic Jour & Engr—Feb., 1905. No. 67596 C.

Parks.

Parks and Parkways. Andrew Wright Crawford. Notes on the park systems of various American cities, with maps and illustrations. 2800 w. Pro Engrs' Club of Phila—Jan., 1905. No. 68005 D.

Pavements.

Brick Pavements. John W. Fulwider. Read before the Indiana Engineering Soc. Gives the writer's views in regard to highway construction and describes the laying of brick pavements, sidewalk construction, &c. 800 w. Munic Engng—Feb., 1905. No. 67729 C.

The Cost of Pavement Openings in New York City. Wisner Martin. Read before the Municipal Club of Brooklyn. Especially discusses the cost of making the openings and repairing, as an argument in favor of the construction of pipe galleries. 2200 w. Eng News—Feb. 23, 1905. No. 67888.

The Good Roads Movement and the Part Paving Brick Should Have in It. R. W. Richardson. Read before the Nat. Brick Mfrs.' Assn. Considers brick road building, the method of construction, cost, and maintenance and related matters. Ills. 2800 w. Brick—Feb., 1905. No. 67843.

What Are the Relative Merits of Cement and Asphalt Fillers for Brick Pavements? H. C. Innes. Read before the Nat. Brick Mfrs.' Assn. A discussion of the proper filler for brick and block pavements. 3700 w. Brick—Feb., 1905. No. 67842.

Refuse.

Refuse Destructors. A report on tests carried out by the Manchester Steam Users' Association, under the supervision of C. E. Stromeyer. 2000 w. Elec Engr, Lond—Jan. 27, 1905. No. 67678 A.

The Municipal Refuse Destructor at Hard, Zurich (Die Städtische Kehrichtverbrennungsansta.t im Hard in Zurich). J. Fluck. Illustrating and describing the design and operation of the refuse disposal plant at Zürich. Two articles. 4000 w. Schweiz Bauzeitung—Jan. 21, Feb. 4, 1905. No. 67964 each B.

Sewerage.

The Sewerage and Drainage Systems of Wheaton, Ill. William B. Ewing. An account of the construction of a system of sewerage and drainage with a septic tank. 1500 w. Eng News—Feb. 2, 1905. No. 67630.

Sewer Farm.

The Pasadena, Cal., Sewer Farm. T. D. Allin. A description of the simple method of sewage disposal which has proved satisfactory from a sanitary standpoint, and remunerative from a financial standpoint. 2200 w. Eng Rec—Feb. 11, 1905. No. 67767.

Sidewalks.

Stone and Brick Sidewalks. J. C. Herring. Directions for the construction of natural stone sidewalks, brick sidewalks, and hexagon block sidewalks. 1800 w. Munic Engng—Feb., 1905. No. 67727 C.

WATER SUPPLY.

Filtration.

A New Form of Filter Gallery at Nancy, France. E. A. Gieseler. An illustrated account of the method of Dr. Imbeaux for remodeling the existing filter gallery at Nancy. 1800 w. Eng Rec—Feb. 11, 1905. No. 67765.

Progress in the Filtration of Public Water Supplies. Charles Brossmann, Jr. Read before the Indiana Engng. Soc. A discussion of the methods of purification, the efficiency of filtration, &c. 3000 w. Munic Engng—Feb., 1905. No. 67728 C.

The Revised Plans for the Purification of the Pittsburg Water Supply. Illustrated description of a proposed plant, one of the largest in the world. noting the unusual features. 4800 w. Eng Rec—Feb. 4, 1905. No. 67655.

The Water Filtration Works at Anderson, Ind. F. B. Leopold. An illustrated detailed description of the plant and its equipment with Jewell filters. 2500 w. Eng Rec—Feb. 4, 1905. No. 67654.

Irrigation.

A Private Irrigation System in Texas. Illustrated detailed description of a system furnishing water to an area of about 15,000 acres, and costing about $1,000,000. 1400 w. Eng Rec—Feb. 18, 1905. No. 67850.

We supply copies of these articles. See page 159.

Pumping Plant.

The New Well and Hydraulic Pumping Plant at Peoria, Ill. Dabney H. Maury. Read before the Illinois Soc. of Engrs. & Surveyors. Illustrates and describes the construction work and the plant. 2000 w. Eng Rec—Feb. 4, 1905. No. 67657.

Purification.

Copper Sulphate and Copper Foil or Copper Vessels for the Treatment of Typhoid-Infected Water. Gives statements by Dr. George T. Moore and Prof. Henry Kraemer in regard to the use of copper or copper compounds as a germicide in potable water. 1600 w. Eng News—Feb. 9, 1905. No. 67708.

The West Riding Rivers Bill. A discussion of the bill to prevent the pollution of streams by trade effluents. 3600 w. Engng—Feb. 3, 1905. Serial. 1st part. No. 67783 A.

Salt Water.

The Use of Salt Water for Fire Protection and Other Purposes at U. S. Navy Yards. Brief descriptions of the systems installed at Norfolk, New York, Puget Sound, and Key West. 2200 w. Eng News—Feb. 2, 1905. No. 67627.

WATERWAYS AND HARBORS.

Canals.

The Canal of the Two Seas (Le Canal des Deux-Mers). Francis Marre. A discussion of the project to cut a canal from Bordeaux, on the Atlantic to Narbonne, on the Mediterranean. Serial. Part I. 4500 w. Revue Technique—Jan. 10, 1905. No. 67922 D.

The Panama Canal and Its Problems. John Barrett. Considers the responsibility of Chief Engineer Wallace, a sea-level or high-level canal, projects for dams and artificial lakes, the securing of competent labor, &c., &c. 7500 w. Rev of Revs—Feb., 1905. No. 67563 C.

Crane.

Floating Shears for the Port of Riga (Bigue Blottante du Port de Riga). Illustrated description of floating pontoon carrying a 65 ton shears and a 7 ton radial crane. 1000 w. 1 plate. Génie Civil—Jan. 28, 1905. No. 67915 D.

Harbor Improvement.

The Improvement of the Port of Manzanillo, Mexico. An illustrated account of a work involving an expenditure of some seven million dollars, on the Pacific coast of Mexico. The work involves the construction of a breakwater, a stone seawall with ten piers, and a canal. 3000 w. Eng News—Feb. 16, 1905. No. 67803.

Nile.

The Navigation of the Nile. Sir William H. Preece. Deals principally with the navigation from Aswan to the sea, the regulation of the currents, depth of water, channels and banks, so that boats may pass up and down stream in all seasons. Discussion. 7000 w. Jour Soc of Arts—Feb. 3, 1905. No. 67777 A.

Regulation.

The Compensating Works of the Lake Superior Power Company. G. F. Stickney. Illustrated description of regulating works including an embankment, a movable dam, a crib dam, and a submerged weir. 6000 w. Pro. Am Soc of Civ Engrs—Feb., 1905. No. 68046 E.

Water Flow.

The Determination of the Normal Profile of Flowing Water (Studie über die Bestimmung der Normalprofile Geschiebeführender Gewässer). Richard Siedek. A study of the relation of the sectional figure of a stream bed and the eroding action of the water flow. Serial. Part I. 4000 w. 1 plate. Zeitschr d Oesterr Ing u Arch Ver—Feb. 3, 1905. No. 67931 D.

The Parabolic Method of Computing Steam Gagings. F. W. Hanna. Explains an application of Simpson's one-third rule to the computation of stream gagings, both for open and frozen streams. 1200 w. Eng News—Feb. 9, 1905. No. 67711.

Wave Action.

Wave Action in Relation to Engineering Structures. D. D. Gaillard. Greatly condensed from Professional Paper No. 31 of the Corps of Engineers, U. S. A. A study of wave action, the effects upon breakwaters and similar structures, &c. Ills. 4700 w. Eng News—Feb. 23, 1905. No. 67885.

ELECTRICAL ENGINEERING

COMMUNICATION.

Exchange.

The New Canal Telephone Exchange at Cincinnati, Ohio. J. E. Peavey. Illustrated description. 1300 w. Elec Rev, N. Y.—Feb. 4, 1905. No. 67623.

Space Telegraphy.

The Development of Wireless Telegraphy. Samuel J. Plimpton. An outline aiming to show how the physicist has been related to the engineer in developing space telegraphy. 2000 w. Yale Sci M—Jan., 1905. No. 67773 C.

We supply copies of these articles. See page 159.

Trees as Antennæ in Wireless Telegraphy. A. Frederick Collins. Illustrations with description of experiments by George O. Squire, Major Signal Corps, U. S. A. 1600 w. Sci Am—Feb. 11, 1905. No. 67713.

Wireless Telegraphy and War Correspondence. Captain Lionel James. An account of the excellent results obtained with the De Forest system in reporting incidents of the war in the East. General discussion. 7500 w. Jour Soc of Arts—Jan. 20, 1905. No. 67526 A.

Wireless Telegraphy Experiments at the Eiffel Tower. Emile Guarini. Brief account of experiments made and proposed. Ills. 1700 w. Sci Am Sup—Feb. 25, 1905. No. 67891.

Telegraph Call.

A Selective Call for Morse Telegraph Systems (Der Wahlweise Anruf in Ruhestrom Morseleitungen). J. Baumann. Describing methods of using either continuous or alternating currents for calls over telegraph lines. 3500 w. Elektrotech Zeitschr—Jan. 26, 1905. No. 67954 B.

Telegraphy.

Breaks in Overland Telegraphic Communication Due to Storms. William Maver, Jr. Discusses some proposed remedies. 3300 w. Cassier's Mag—Feb., 1905. No. 67667 B.

Through Wheatstone Working Over a Line of 4,000 Miles. T. W. Stratford-Andrews. Concerning the Indo-European telegraph line; some of the difficulties met with, method of working, &c. Map. 1600 w. Elec Rev, Lond—Jan. 20, 1905. No. 67534 A.

DISTRIBUTION.

Cables.

Some Points on the Selection of Electric Cables. L. B. Atkinson and C. J. Beaver. Abstract of a paper read before the Manchester Sec. of Elec. Engrs. Deals with the subject from the standpoint of the buyer and user, describing the insulation of cables principally. Short discussion. 4800 w. Elec Engr, Lond—Feb. 10, 1905. No. 67870 A.

The Heat Conductivity of Twisted Cables (Ueber die Wärmeleitung in einem Verseilten Kabel). Gustav Mie. A mathematical examination of the transmission of heat through cables made up of several strands, deducing precise and approximate formulas. 6000 w. Elektrotech Zeitschr—Feb. 6, 1905. No. 67959 B.

Comparison.

Direct Current versus Alternating Current Distribution. O. M. Rau. Read before the Northwestern Elec. Assn. Compares the efficiencies of the two systems, the cost of installation, &c., concluding in favor of the alternating current. 1800 w. Elec, N. Y.—Feb. 1, 1905. No. 67562.

Costs.

Distribution and Dollars. C. H. Williams. Read before the N.-W. Elec. Assn. An analysis of the factors that affect the cost of distribution, the losses to be guarded against, &c. 6800 w. Elec Rev, N. Y.—Feb. 11, 1905. No. 67749.

Madison, Wis.

Central Station Distribution. Full abstract of paper by C. H. Williams, read before the Northwestern Electrical Assn., describing practice in Madison, Wis., and discussing good practice. 3000 w. Elec Wld & Engr—Jan. 28, 1905. No. 67561.

Motor-Generator.

Some Tests Conducted With an Electrolytic Rectifier and Motor-Generator. Horace Boot. An illustrated account of comparative tests of the electrolytic rectifier *v.* an alternating current motor driving a direct current dynamo, for the purpose of charging the accumulators of a large electric car. 1500 w. Elec Rev, Lond—Feb. 10, 1905. No. 67871 A.

Overhead Mains.

The Value of Overhead Mains for Electric Distribution in the United Kingdom. G. L. Addenbrooke. An investigation of the overhead distribution problem, its cost, advantages. &c. Also an appendix giving the Italian law for the transmission to a distance of electric currents. 12300 w. Inst of Elec Engrs—Feb. 9, 1905. No. 67873 D.

South Wales.

District Electric Power Distribution. An illustrated description of the system of the South Wales Electric Power Distribution Company, especially describing the Treforest power house and its equipment. Also the sub-stations. 2800 w. Elec Wld & Engr—Jan. 28, 1905. No. 67558.

Sub-Station.

The Fisher-Street Sub-Station of the Metropolitan Electric Supply Co. Illustrated description of the largest sub-station with rotary machinery, running in England. Its present capacity is 3,000 kw., and it is to be increased to 5,000 kw. Its interesting features are noted. 3000 w. Elect'n, Lond—Jan. 20, 1903. No. 67538 A.

Switchgear.

A British Switchgear for Sub-Station Control. Illustrated description of the switch gear of the Fisher Street sub-station, London. 5000 w. Elec Wld & Engr—Feb. 18, 1905. No. 67864.

We supply copies of these articles. See page 159.

ELECTRO-CHEMISTRY.

Electric Furnaces.

Resistance Furnace for Crucibles. Francis A. J. FitzGerald. Describes the general methods of construction of a crucible furnace, and compares it with a commercially worked furnace, giving experiments. Ills. 4200 w. Elec-Chem & Met Ind—Feb., 1905. No. 67620 C.

The Electric Furnace in the Iron and Steel Industry. Auguste J. Rossi. A letter discussing the metallurgical side of the question, the cost, &c. 1700 w. Elec-Chem & Met Ind—Feb., 1905. No. 67619 C.

Electro-Metallurgy.

Electro-Metallurgy in 1904. A survey of the year's progress in these industries. 2500 w. Engr, Lond—Feb. 10, 1905. No. 67882 A.

Electroplating.

Electroplating. Herbert J. Hawkins. An explanation of up to date methods. 1200 w. Met Work—Feb. 18, 1905. Serial. 1st part. No. 67817.

Progress.

Progress in Electro-Chemistry and Electro-Metallurgy in 1904. John B. C. Kershaw. A review in detail. 1800 w. Elec Rev, Lond—Jan. 20, 1905. Serial. 1st part. No. 67537 A.

ELECTRO-PHYSICS.

Cast Iron.

The Magnetic Properties of Cast Iron (Magnetische Eigenschaften des Gusseisens). H. Nathusius. Data and results of investigations into the permeability, remanence, and other magnetic properties of cast iron with relation to the chemical constitution. Serial. Part I. 2500 w. Stahl u Eisen—Jan. 15, 1905. No. 67936 D.

Electric Waves.

The Schloemilch Wave Detector. Illustrated description of an apparatus devised by W. Schloemilch, based on the sensitiveness of polarization cells to electric waves. 1400 w. Sci Am Sup—Feb. 18, 1905. No. 67813.

Wave Distortion on Transmission Lines. William S. Franklin. Abstract of a lecture before the N. Y. Elec. Soc. A discussion of the wave piston, with diagrams. 2500 w. Elec Rev, N. Y.—Feb. 11, 1905. No. 67751.

Electromotive Force.

The Computation of the Effective Electromotive Force of Polyphase Machines (Ueber die Berechnung der Effektiven Elektromotorischen Kraft von Drehstrommaschinen). Arthur Müller. A mathematical investigation, deriving formulas, and computing a table of factors for a three-phase alternator. 2000 w. Zeitschr f Elektrotechnik—Jan. 15, 1905. No. 67961 D.

Fog Dispersion.

Fog Dispersion by Electricity. Describes the process worked out by Sir Oliver Lodge, illustrating the apparatus used. 1800 w. Sci Am—Feb. 11, 1905. No. 67712.

Magnetization.

The Conversion of Energy in the Magnetization and Electrification of Media (Energieumwandlung während der Magnetisierung und Elektrisierung von Medien). Dr. Johann Sahulka. A mathematical study based upon experiments with permanent magnets and with electrical condensers. 5000 w. Elektrotech Zeitschr—Feb. 2, 1905. No. 67957 B.

Radioactivity.

A New Radioactive Mineral (Sur un Nouveau Minéral Radifère). J. Danne. Describing radioactive minerals containing lead, discovered near Issy-l'Evêque, in France, the principal one being pyromorphite, containing no uranium. 800 w. Comptes Rendus—Jan. 23, 1905. No. 67920 D.

The Radioactive Deposits at Issy l'Evêque (Les Gisements Radifères d'Issy l'Evêque). Jacques Danne. Describing deposits of argile, permatite, and pyromorphite, minerals containing lead and no uranium, but having a marked radioactivity. 1500 w. Génie Civil—Jan. 21, 1905. No. 67912 D.

GENERATING STATIONS.

American Plants.

Description of Some Plants Inspected During a Recent Visit to the States. H. L. Risley. Describes apparatus that appeared to differ from British practice, especially single-phase traction motors. 3600 w. Elec Engr, Lond—Jan. 20, 1905. No. 67533 A.

Armatures.

Armature Winding for Constant Potential Direct-Current Machinery. Illustrates and describes the types of standard windings. 2500 w. Elec Club Jour—Feb., 1905. No. 67823.

Armature Windings of the Closed Circuit Type. William Cramp. An illustrated series of articles examining reentrant windings. 1400 w. Elec Engr, Lond—Jan. 20, 1905. Serial. 1st part. No. 67531 A.

California.

The Power Plants of the Edison Electric Company of Los Angeles. The first of a series of articles giving illustrated descriptions of the hydroelectric and the

We supply copies of these articles. See page 159.

steam stations of this extensive system for supplying light and power in seven counties of Southern California. 3200 w. Eng Rec—Feb. 25, 1905. Serial. 1st part. No. 68038.

Chattanooga, Tenn.

The Power Plant of the Chattanooga Electric Company, Chattanooga, Tenn. Illustrates and describes an important addition, with the installation of Curtis steam turbines, and other novel features. 1800 w. Elec Rev, N. Y.—Feb. 25, 1905. No. 68035.

Chelsea.

The Chelsea Generating Station of the London Underground Railways. An illustrated description of this power station. 2000 w. Eng Rec—Feb. 25, 1905. No. 68040.

Commutators.

Refilling and Repairing Commutators. Arthur B. Weeks. Gives an instance illustrating the importance of using the best material, describing methods of repair. 1600 w. Am Elect'n—Feb., 1905. No. 67614.

Cut-Outs.

Discriminating Relays and Cut-Outs: A Reply to Mr. M. B. Field. Leonard Andrews. A critical discussion of devices for isolating a faulty generator. 1800 w. Elec Rev, Lond—Feb. 3, 1905. No. 67781 A.

Detroit.

Central Station Work in Detroit. Begins an illustrated description of a large central generating plant with its equipment and the use of steam engines at certain sub-stations, and the supply of steam heat from these stations, and other features of interest. 4500 w. Elec Wld & Engr—Feb. 4, 1905. Serial. 1st part. No. 67658.

Dynamos.

Development of the Unipolar Dynamo. James Asher. Brief review of the development in unipolar dynamos since 1831, describing briefly the types. 1100 w. Elec Wld & Engr—Feb. 4, 1905. No. 67659.

Hartford.

The Dutch Point Plant of the Hartford Electric Light Company. Illustrated detailed description of a steam-turbine electric central station of 4,000 kw. rated capacity, interesting because of its rapid erection and because of details in design, arrangement of turbine and boiler rooms, and systems of steam piping. 3500 w. Eng Rec—Feb. 25, 1905. No. 68036.

High-Tension.

A Recent High-Tension Installation. A. E. Buchenberg. Illustrates and describes a recent electrical high-tension plant installed at Martinsburg, W. Va. 1500 w. Engr, U. S. A.—Feb. 15, 1905. No. 67835 C.

Hydro-Electric.

A Norwegian Hydro-Electric Plant. Brief illustrated description of a new plant at Christiania, Norway. 1800 w. Elec Wld & Engr—Feb. 11, 1905. No. 67762.

Construction of Canadian Niagara Power Company's 100,000 H. P. Hydro-Electric Plant at Niagara Falls, Ont. Cecil B. Smith. Illustrated detailed description of the construction and equipment. 9 plates. 8500 w. Can Soc of Civ Engrs—Jan., 1905. No. 67899 D.

Opening of the Niagara Canadian Power Company's Plant. An illustrated account of the starting of the initial units of this plant. 1100 w. Sci Am—Feb. 4, 1905. Serial. 1st part. No. 67660.

The Hohenfurth Electric Station of Spiro & Sons (Elektrizitätswerk Hohenfurth der Firma I. Spiro & Söhne in Krumman). Dr. J. Puluj. Fully illustrated description of a plant taking 2,300 h. p. from the Moldau and transmitting it to the Spiro paper mills, 25 kilometres distant. 3500 w. Zeitschr f Elektrotechnik—Jan. 22, 1905. No. 67962 D.

The Hyrdo-Electric Power Plant of the North Mountain Power Co. An illustrated detailed description of a twenty-five cycle installation which is to serve Humboldt Bay and Eureka, in California. 3000 w. Jour of Elec—Feb., 1905. No. 67798 C.

The Successful Joint Utilization of Several Small Water Powers. W. B. Jackson. Remarks on recent changes with respect to sources of power, describing the system of the Janesville Electric Company which has details of interest. 2200 w. Am Gas Lgt Jour—Feb. 13, 1905. No. 67755.

Indian Territory.

The Gas and Electric Plant at Muskogee, I. T. Brief illustrated description of a gas and electric and ice plant installation. 700 w. Elec Rev, N. Y.—Feb. 11, 1905. No. 67750.

Isolated Plant.

Mechanical Plant of a Power Building in Providence, R. I. Illustrated description of the plant for furnishing heat, light, and power for a five-story mill-construction building. 1800 w. Eng Rec—Feb. 11, 1905. No. 67770.

The Electrical Equipment of the Hotel Astor, New York. W. E. Crane. An illustrated detailed description of the engineering equipment of this fine hotel, especially the electrical plant. 2500 w. Elec Wld & Engr—Feb. 11, 1905. No. 67761.

We supply copies of these articles. See page 159.

Load Factor.

Effect of Load Factor on Cost of Power. Abstract of a paper by E. M. Archibald, read before the Canadian Soc. of Civ. Engrs. Discusses the effect of load factor on the cost of producing power, the cost of management, and distribution. 2500 w. Elec Wld & Engr—Feb. 11, 1905. No. 67764.

The Influence of "Load-Factor" on the Cost of Electrical Energy. Edmund L. Hill. Gives an explanation of the meaning of "load factor" showing its effect on the economy of the system. 3300 w. Elect'n, Lond—Feb. 10, 1905. No. 67874 A.

Munich.

The Electric Plants of the City of Munich (Die Elektrizitätswerke der Stadt München). K. Meyer. A general description of the electric generating and transforming stations in Munich. Serial. Part I. 3000 w. Zeitschr d Ver Deutscher Ing—Jan. 14, 1905. No. 67900 D.

Providence, R. I.

The Narragansett Electric Lighting Company's Plant. Illustrated detailed description of the plant which supplies current for light and power to the city of Providence, R. I., and the territory included in a circle of about fifteen miles radius. 2800 w. Elec Rev, N. Y.—Feb. 11, 1905. No. 67748.

Switchboards.

Accuracy Checks of Switchboard Instruments. Clayton H. Sharp. Considers the derangements liable to occur in switchboard instruments and the necessity for periodic checking, and the methods. 2800 w. Elec Rev, N. Y.—Feb. 11, 1905. No. 67752.

Switchboard Connections of Compound-Wound Generators. H. M. Gassman. Discusses the scheme of connections. Ill. 500 w. Am Elect'n—Feb., 1905. No. 67615.

Transformer Oil.

Some Hints About Transformer Oil. C. E. Skinner. Directions for filling transformer cases with oil. 1500 w. Elec Club Jour—Feb., 1905. No. 67824.

LIGHTING.

Arcs.

Series Alternating Arc Lighting. E. P. Warner. Read at the convention of the Northwestern Elec. Assn., at Milwaukee, Wis. Considers the requirements of a modern system of arc lighting, the desirable features in the series alternating lamp, and the results achieved. 3700 w. Elec Rev, N. Y.—Feb. 4, 1905. No. 67625.

The Light Emission from the Arcs of Intensive Arc Lamps (Ueber die Lichtausstrahlung von Lichtbögen in Intensivbogenlampen). Berthold Monasch. An examination of the distribution of illumination from arc lamps with impregnated carbons arranged in an inclined position. 5000 w. Elektrotech Zeitschr—Jan. 19, 1905. No. 67951 B.

Illumination.

Progress in the Technology of Illumination (Fortschritte in der Beleuchtungstechnik). Dr. W. Wedding. An address before the Electrical Society of Cologne, reviewing the development of the latest forms of oil, gas, and electric lighting, with a comparison of their relative efficiency. 3500 w. Elektrotech Zeitschr—Jan. 19, 1905. No. 67953 B.

London Coliseum.

The London Coliseum. An illustrated article describing the electric equipment of a large place of amusement, especially the stage lighting and power. 4000 w. Elect'n, Lond—Jan. 27, 1905. No. 67684 A.

Nernst.

The Nernst Lamp. E. R. Roberts. Explains the principle of this lamp giving information concerning its recent development. General discussion. 4000 w. Pro Engrs' Soc of W Penn—Jan., 1905. No. 67795 D.

Tantalum Lamp.

Tantalum and the Tantalum Lamp. Gives information of an investigation carried out by Dr. W. von Bolton, of the preparation and properties of pure tantalum which has a very high melting point, discussing the chemical side of the subject. 800 w. Elec-Chem & Met Ind—Feb., 1905. No. 67618 C.

The New Tantalum Lamp of Siemens & Halske (Die Tantallampe eine Neue Glühlampe der Firma Siemens & Halske A. G.). W. von Bolton & O. Feuerlein. With illustrations of the incandescent lamp using tantalum as the luminous element. Data of illumination and endurance are given. 4000 w. Elektrotech Zeitschr—Jan. 26, 1905. No. 67956 B.

The Tantalum Incandescent Lamp. A detailed account of a new lamp in which tantalum is used for the filament. Editorial comment. Ills. 4000 w. Elec Wld & Engr—Jan. 28, 1905. No. 67560.

The Tantalum Lamp of Messrs. Siemens & Halske. Dr. W. v. Bolton and Dr. O. Feuerlein. Abstract of a paper read before the Elektrotechnische Verein at Berlin. An account of the experimental investigations, and an illustrated description of the tantalum lamp, its electric and photometric properties, and its behavior in actual use. 4000 w. Elec Rev, Lond—Jan. 27, 1905. No. 67682 A.

The Tantalum Lamp (Die Tantallampe). E. Budde. A brief description

We supply copies of these articles. See page 159.

of the Siemens & Halske tantalum incandescent lamp, with data of performance. 2000 w. Zeitschr f Elektrotechnik—Jan. 29, 1905. No. 67963 D.

MEASUREMENT.

Calibration.

Calibration of Voltmeters and Ammeters. L. A. Freydenberger. Describes a method particularly applicable to voltmeters of the double-scale type. 1500 w. Elec Wld & Engr—Feb. 11, 1905. No. 67763.

Electrical Waves.

De Forest-Ives Electric Wave-Length Standard. A. Frederick Collins. Illustrated description of instrument and its operation. It is said to be capable of measuring any length of wave employed in the present practice of wireless telegraphy. 1500 w. Sci Am Sup—Feb. 4, 1905. No. 67663.

Electroscopes.

The Construction of Simple Electroscopes for Experiments on Radioactivity. O. W. Richardson. An illustrated description of simple electroscopes. 2200 w. Nature—Jan. 19, 1905. No. 67525 A.

Losses.

The Retardation Method of Measuring Losses in Electric Motors and Generators. Frederick W. Seringhaus, Jr., and Gerard B. Werner. Gives in detail the results of an investigation of this method, made at Columbia Univ. 2000 w. Sch of Mines Qr—Jan., 1905. No. 68010 D.

Oscillograph.

Kinematic Representation of Current Curves by Means of the Luminous Discharge Oscillograph (Kinematographische Aufnahmen einiger Stromkurven mittels Glimmlicht-Oscillographen). Ernst Ruhmer. Describing an instrument using the luminous effect in a Geissler tube for showing the phase action of the current. 1800 w. Elektrotech Zeitschr—Feb. 9, 1905. No. 67960 B.

Self-Inductance.

Measurements of Self-Inductance. J. B. Whitehead and H. D. Hill. Reports investigations made of the methods for the measurement and comparison of self-inductance capacity and mutual inductance published by Prof. Rowland, to determine their value. 3800 w. Am Jour of Sci—Feb., 1905. No. 67589 D.

Wattmeters.

Null Wattmeter Methods of Measuring Power. Albert Campbell. Brief description of two novel methods of measuring power. 700 w. Elec Rev, Lond—Jan. 27, 1905. No. 67680 A.

The Choice of Signs in Wattmeter Problems. L. A. Freudenberger. Giving rules for constructing vector diagrams from the wattmeter readings to enable the values and phase positions of the currents in a three-phase network to be determined. 1400 w. Elec Wld & Engr—Feb. 18, 1905. No. 67866.

MOTORS.

"Balancer."

The "Balancer" as Employed in Multiple-Voltage Direct-Current Systems. A. E. Kennelly. Describes the balancer and its general arrangement and applications for effecting speed control of motors in the shop. 1500 w. Harvard Engng Jour —Jan., 1905. No. 67598 C.

Brewery Plant.

Power Plant of the Anheuser-Busch Brewing Association at St. Louis. Illustrates and describes a plant with a capacity of 1,400 kilowatts, to furnish power for direct-current motors which drive the various machines, and for lighting. 1500 w. Engr, U. S. A.—Feb. 1, 1905. No. 67610 C.

Diagram.

A Working Diagram of the Alternating Current Synchronous Motor. A. E. Kennelly. Gives a graphical method of representing the relations between the e. m. f.'s, currents and power in a single-phase synchronous-motor circuit, applicable to three-phase motor systems. Also editorial. 2000 w. Elec Wld & Engr—Jan. 28, 1905. No. 67559.

Electric Driving.

An Electrically Driven Flour Mill. O. C. McMeans. Read before the Indiana Engng. Soc. Describes the equipment of the flouring mill plant of the Urban Milling Co., of Buffalo, which uses power from Niagara. 2000 w. Eng Rec—Feb. 11, 1905. No. 67766.

Electric Drive. E. L. Walker. A discussion of variable speed motors and the methods of applying them to machine tools. Also general discussion. Ills. 5600 w. Pro Engrs' Club of Phila—Jan., 1905. No. 68006 D.

The Electrical Operation of Textile Factories. H. W. Wilson. Abstract of a paper before the Manchester Sec. of the Inst. of Elec. Engrs. States the advantages claimed for electrical driving, discussing cost, reliability, &c. 3000 w. Prac Engr—Jan. 27, 1905. Serial. 1st part. No. 67676 A.

Induction Motors.

A New Design for Slow Speed Induction Motors. Prof. Clarence P. Feldmann. Brief illustrated description of a German design of a double motor for

We supply copies of these articles. See page 159.

draining pumps in mines. 700 w. Elec Wld & Engr—Feb. 18, 1905. No. 67865.

Magnetic Brake.

Design for a Magnetic Brake for a 15 Horse-Power, 500-Volt Motor. R. A. Greene. Section, and description. 1200 w. Am Mach—Vol. 28, No. 8. No. 68017.

Motor Equipments.

Two-Motor versus Four-Motor Equipments. N. McD. Crawford. A report of an investigation made, describing the line and conditions of service on which the tests were made. 1200 w. Am Inst of Elec Engrs—Feb. 24, 1905. No. 68002.

Regulation.

Some Tests on the Use of the Synchronous Motor in Compensating for Lagging Currents in a Circuit. E. A. Regestein. Explains the considerations involved and describes tests made by the writer. 1800 w. Elec Rev, N. Y.—Feb. 25, 1905. No. 68034.

Repulsion Motor.

A New Repulsion Motor and its Preliminary Computations (Ein Neuer Repulsions-Motor und Seine Vorausberechnung). Karl Schnetzler. A discussion of the problems connected, the windings, the position of the brushes, and the dimensions for required power and regulation. Two articles. 6000 w. Elektrotech Zeitschr—Jan. 19, 26, 1905. No. 67952 each B.

Single-Phase.

Single-Phase Motors on Polyphase Systems. H. W. Doubrava. Discusses recent action in regard to the use of single-phase motors, the reasons for and against their use, the saving in cost, &c. 3200 w. Elec Rev, N. Y.—Feb. 18, 1905. No. 67829.

See Street and Electric Railways.

Small Motors.

The Widening Use of Small Electric Motors. F. H. Kimball. An illustrated article referring specially to American practice. 1500 w. Cassier's Mag—Feb., 1905. Serial. 1st part. No. 67666 B.

Three-Phase.

The Gromo-Nembro Power-Plant. Emile Guarini. Illustrated description of the three-phase 40,000-volt power-transmission from Gromo to Nembro (Lombardia), said to be the first plant of its kind in Europe. 2500 w. Cent Sta—Feb., 1905. No. 67716.

Variable Speed.

Variable Speed Motors. C. L. Sumpter. An illustrated article calling attention to characteristics of the direct current motors and their application. 1400 w. Elec Rev, Lond—Jan. 27, 1905. No. 67681 A.

TRANSMISSION.

Aluminium.

Aluminium. W. Smith. Read before the Birmingham Electric Club. Reviews the history of this metal and discusses its value as an electrical conductor, and other uses. Ills. 2500 w. Elec Engr. Lond—Jan. 27, 1905. No. 67679 A.

Insulation.

The Insulation of Armature or Other Coils for High Tension Apparatus. J. S. Highfield. An account of an investigation made of the breakdown of insulation, proving it to be due to the formation of nitric acid by brush discharge causing ozonization of the air. 1200 w. Elect'n, Lond—Jan. 27, 1905. No. 67683 A.

Power Transmission.

The Maximum Distance to Which Power Can Be Economically Transmitted. Discussions at New York and at Pittsburg of recent paper by Ralph D. Mershon. 10500 w. Am Inst of Elec Engrs—Feb., 1905. No. 68003 C.

Wire Stresses.

A Dynamometer for the Measurement of Stresses in Overhead Wires (Ein Dynamometer zur Messung der Drahtspannung in Freileitungen). George Nicolaus. The stress is measured by determining the force required to produce a certain lateral deflection. 1000 w. Elektrotech Zeitschr—Feb. 2, 1905. No. 67958 B.

INDUSTRIAL ECONOMY

Canada.

The Development of Canada. George W. Colles. A review of the history of Canada and the causes that have affected its development, giving much information of the resources and recent changes. 5000 w. Cassier's Mag—Feb., 1905. No. 67665 B.

China.

Mines and Railways in China. Comments on conditions in China, and the recent change of the control of mines and railways to the lately-created Board of Commerce. 1400 w. Aust Min Stand—Jan. 5, 1905. Serial. 1st part. No 67868 B.

Cost Keeping.

Cost Keeping on General Contract Work. A. W. Buel. Describing methods for use in outdoor and general construc

We supply copies of these articles. See page 159.

tion work, showing their value in furnishing prompt and accurate information. 3500 w. Engineering Magazine—March, 1905. No. 67970 B.

Radiator Costs. R. W. M'Dowell. An example of foundry cost accounting, explaining the system. 2300 w. Foundry—Feb., 1905. No. 67592.

Education.

Desirable Entrance Requirements for Engineering Colleges. William Kent. Read before the Am. Assn. for the Adv. of Science. Information in regard to recent changes made, in the requirements for entrance, with opinions from several writers and other remarks. 2500 w. Eng News—Feb. 2, 1905. No. 67628.

Electrical Education in the French Universities (L'Enseignement Electrotechnique dans les Universités Françaises). C. Carmichel. A review of French educational methods in technology, with especial reference to electrical engineering. Serial. Part I. 3000 w. Revue Technique—Jan. 25 1905. No. 67924 D.

The Training of the Electrical Engineer. Dr. Louis Bell. A discussion of the qualities needed by a successful electrical engineer and the best means of acquiring them. 4400 w. Cassier's Mag—Jan., 1905. No. 67585 B.

Government Control.

Government Control of Railroad Earnings. L. F. Day. Discusses unwise legislation affecting railway rates, opposing the giving of the rate-making power to the Interstate Commerce Commission. 5000 w. Ry Age—Feb. 10, 1905. No. 67738.

Japan.

The Commerce and Mineral Industry of Japan (Le Japon: Son Commerce—Son Industrie Minière). Francis Marre. A tabulated review of Japanese commerce and metallurgical products. 1800 w. Revue Technique—Jan. 25, 1905. No. 67923 D.

Labor.

The Compensation of Labor. H. L. Gantt. A discussion of piece work, premium and bonus systems, showing that all wage systems are simply expedients to make employer and employee see the facts in the same light. 2800 w. Engineering Magazine—March, 1905. No. 67976 B.

The Employment and Preparation of Firemen. E. W. Pratt. Discusses mainly the personality and character of the men, method of hiring and educating the men, &c. General discussion. 17000 w. Pro W Ry Club—Jan. 17, 1905. No. 67722 C.

Mathematics.

Engineering Mathematics. E. Sherman Gould. Illustrates the part mathematics plays in developing engineering formula, claiming that it is the basis of all scientific engineering. 3000 w. Cassier's Mag—Jan., 1905. No. 67586 B.

Ownership.

Who Own the Railroads? H. T. Newcomb. Gives a memorandum of the results of a recent investigation which disproves the erroneous impression that railroad ownership is vested in a small group of the very rich. 2000 w. R R Gaz—Vol. XXXVIII, No. 8. No. 68024.

Patents.

Facts Concerning Patents Not Generally Understood, or of General Interest to Engineers. Frederick W. Winter. An explanation of the patent system in the United States and much information of interest. General discussion. 9500 w. Pro Engrs' Soc of W Penn—Jan., 1905. No. 67796 D.

Securities.

Electric Railway Securities as Investments. From a paper by Albert L. Kramer, in *The Annals of the American Academy of Political and Social Science.* Deals with companies in operation of city and interurban lines. 2400 w. R R Gaz—Vol. XXXVIII, No. 6. No. 67720.

MARINE AND NAVAL ENGINEERING

Battleships.

Some Vessels of the Russian Baltic Fleet. Engravings of seven of the vessels belonging to this fleet, noting their leading features, and giving brief descriptions. 350 w. Engr, Lond—Jan. 20, 1905. No. 67542 A.

Car Ferry.

Car Ferry Detroit. Illustrated detailed description of an interesting vessel, especially with reference to the machinery. 2200 w. Marine Rev—Feb. 9, 1905. No. 67736.

Cruisers.

Armoured Cruisers. Discusses the construction of the "Edgard Quinet" as an example, giving a comparative table of types, and considers its value in warfare. 2200 w. Engr, Lond—Feb. 3, 1905. No. 67788 A.

Docks.

Floating Docks. Lyonel E. Clark. Ab-

stract of a paper read before Inst. of Civ. Engrs., England. Describes types, and discusses the problems in design, the advantages and disadvantages, &c. 2000 w. Eng Rec—Feb. 25, 1905. No. 68041.

Fire Boat.

Fire Launch. Illustrated description of a powerful salvage vessel for service on the Manchester Ship Canal. 700 w. Engr, Lond—Feb. 10, 1905. No. 67883 A.

Ice Breakers.

Ice Breakers on Lower St. Lawrence. G. M. Fairchild, Jr. States the conditions on this river and gives information in regard to an ice-breaking service aiming to lengthen the season of navigation. Illustrated description of the ice-breaker "Montcalm." 2800 w. Marine Rev—Feb. 23, 1905. No. 68027.

Liners.

The Cunard Liner Caronia. An account of this new vessel, giving an idea of the arrangement and comfort made possible, and the features of special interest. 2000 w. Engr, Lond—Jan. 27, 1905. No. 67695 A.

The New Cunard Liners. Editorial discussion of the Caronia and Carmonia, and their machinery. Ills. 3000 w. Engng—Feb. 10, 1905. No. 67878 A.

Mercantile Marine.

The Making of the British Mercantile Marine. Brysson Cunningham. Information based on shipbuilding statistics of the last half-century, comparing the activity in England with other countries, and illustrating vessels, shipbuilding yards and appliances. 2500 w. Cassier's Mag—Jan., 1905. No. 67587 B.

Motor Boats.

A Gasoline Warship Launch. Illustrated description of an interesting Napier launch. 1200 w. Sci Am Sup—Feb. 11, 1905. No. 67715.

Internal-Combustion-Engine Launches. Illustrations and brief descriptions of boats of this class and their equipment. 1500 w. Engng—Feb. 3, 1905. No. 67784 A.

Motor-Boats at the Paris Automobile Show. An illustrated article describing characteristics of the exhibits. 2400 w. Engng—Jan. 27, 1905. No. 67689 A.

Successful Motor-Driven Canal Boat. Brief illustrated description of a boat propelled by a three cylinder gasoline engine of 21 h. p., which drives a 28-in. 3-bladed propeller. The design and construction of the hull and arrangement of the propeller are quite new. 500 w. Naut Gaz—Feb. 2, 1905. No. 67700.

Salvage.

The Salvage of Ships. Outlines briefly the history and administration of the Liverpool Salvage Assn., which has been in existence for 47 years, and describes the work carried out, illustrating the equipment. 3500 w. Engng—Jan. 20, 1905. Serial. 1st part. No. 67544 A.

Scouts.

The New Scouts for the King's Navy. Illustrated description of the "Sentinel," with report of the trials, and discussion of designs for this class of vessels. 2500 w. Engng—Feb. 3, 1905. No. 67785 A.

Shipbuilding.

Electric and Pneumatic Portable Tools in Shipbuilding. Frank C. Perkins. An illustrated article describing the operation of various tools. 800 w. Marine Engng—Feb., 1905. No. 67569 C.

Shipping.

Improvements in Shipping Ports. An illustrated description of recently completed improvements and those in progress in British ports. 3800 w. Ir & Coal Trds Rev—Jan. 27, 1905. Serial. 1st part. No. 67696 A.

Sidewheel.

The Sidewheel Steamship Old Dominion. Illustrated description of the last example of a type of ocean steamer which at one time predominated. 3300 w. Naut Gaz—Feb. 2, 1905. No. 67699.

Steering Gear.

Details of Electric Steering Gear of the Turbine Steamer "Manxman." Illustrated description of a combination of steam and electric steering gear fitted on board of this turbine-driven steamer. 1500 w. Engng—Feb. 17, 1905. No. 68053 A.

MECHANICAL ENGINEERING

AUTOMOBILES.

Beeston-Humber.

Two New Beeston-Humber Cars. Illustrated detailed descriptions of two new designs. 2000 w. Autocar—Feb. 11, 1905. No. 67867 A.

Belsize.

The Belsize—All British—Petrol Cars. Begins an illustrated detailed description of models of these cars. 1800 w. Auto Jour—Jan. 28, 1905. Serial. 1st part. No. 67672 A.

We supply copies of these articles. See page 159.

Brotherhood.

The 20-H. P. Brotherhood Petrol Car—Another New All-British Vehicle. An illustrated detailed description. 3000 w. Auto Jour—Feb. 4, 1905. Serial. 1st part. No. 67778 A.

Chenard-Walcker.

The 15 H. P. Chenard-Walcker Car. Illustrated description of a British car remarkable for silent running, simplicity of control, and flexibility of engine. 1000 w. Autocar—Jan. 21, 1905. No. 67529 A.

Delaunay-Belleville.

The Delaunay-Belleville Cars. Illustrates and describes interesting details of these cars. 1000 w. Autocar—Jan. 28, 1905. No. 67673 A.

Exhibition.

The Motor-Car Exhibition. An account of the third motor-car show promoted by the Society of Motor Manufacturers and Traders, held at Olympia, London. Describes many of the vehicles. Ills. 5000 w. Engng—Feb. 17, 1905. Serial. 1st part. No. 68052 A.

The Progress of Automobilism in 1904 (Les Progrès de l'Automobilisme en 1904). F. Drouin. Reviewing especially the developments of the year as shown in the exhibits at the recent Salon in Paris. Serial. Part I. 3000 w. Génie Civil—Jan. 28, 1905. No. 67914 D.

Gasoline Car.

The Heaviest Gasoline Propelled Vehicle in the World. Emile Guarini. Illustration and brief description of the gasolene electric motor coaches put in service on the North-Eastern Railway of England. 700 w. Ry & Loc Engng—Feb., 1905. No. 67583 C.

Industrial Vehicles.

The Latest Types of Industrial Motor Vehicles. Lucien Périssé. A review of Continental and British practice, with numerous illustrations of successful freight and passenger automobiles. 4500 w. Engineering Magazine—March, 1905. No. 67974 B.

Spring-Wheels.

Spring-Wheels for Motor Cars. Introductory remarks, and the commencement of an illustrated detailed description of the Halford spring-wheel is given in the present article. 3300 w. Auto Jour—Jan. 21, 1905. Serial. 1st part. No. 67530 A.

COMBUSTION MOTORS.

Gas Engines.

Gas Engine Economy. George Miller. Remarks on the effect on economy due to the position of the igniter. 1700 w. Mach, N. Y.—Feb., 1905. No. 67550 C.

Large Gas Engines (Ueber Gross-Gasmaschinen). Dr. Eugen Meyer. An address reviewing the development of the gas engine on the Continent, with illustrations of a number of engines of 1,000 h. p. and over. Two articles. 8000 w. 4 plates. Stahl u Eisen—Jan. 15, Feb. 1, 1905. No. 67932 each D.

The Internal Combustion Engine. J. R. Bibbins. Abstract of a paper read before the Modern Science Club, Brooklyn, N. Y. Discusses its principles and uses, new fields, performance, &c. Ills. 2200 w. Elec Rev, N. Y.—Feb. 4, 1905. No. 67624.

The Letombe Gas Engine System. Emile Guarini. Illustrates and describes the Letombe pressure gas producer and the system of regulation. 1500 w. Engr, U. S. A.—Feb. 15, 1905. No. 67838 C.

Ignition.

Ignition Troubles and Remedies. R. L. Hubler. Considers in detail the parts of a complete igniting outfit and the troubles that may arise, with the remedies. Especially referring to launch motors. 4800 w. Rudder—Feb., 1905. No. 67578 C.

Locomotives.

Application of the Gas Engine to the Locomotive and Steamship. A brief digest of a study of this problem by Peter Eyermann. 1000 w. Sci Am Sup—Feb. 4, 1905. No. 67662.

Gasoline Locomotives and Cars for Railroads. Illustrates and describes experimental vehicles on trial in England in the effort to solve the problem of economical operation of short lines. 2200 w. Sci Am Sup—Feb. 18, 1905. No. 67809.

Suction Gas.

The Pintsch Suction Gas Producer. S. F. Seager. Abstract of a paper read before the Mich. Engng. Soc. Illustrated detailed description of the present Pintsch suction gas plant and its operation. 2000 w. Eng News—Feb. 16, 1905. No. 67804.

HEATING AND COOLING.

Refrigeration.

Cold Storage at Scranton. Illustrated description of the Scranton Cold Storage and Warehouse Co.'s plant and its equipment. 1000 w. Ice & Refrig—Feb., 1905. No. 67651 C.

Steam Heating.

The Mechanical Plant of Simmons College, Boston. K. S. Howard. Brief description, with illustration showing the arrangement of the indirect heating apparatus. 1500 w. Eng Rec—Feb. 11, 1905. No. 67769.

We supply copies of these articles. See page 159.

Vacuum System.

Vacuum System of Heating. William Kavanagh. Detailed description of this system, with statement of its advantages. Ills. 2500 w. Engr, U. S. A.—Feb. 1, 1905. No. 67611 C.

Ventilation.

Air Purification in the Ventilating Plant of the City Hall, St. Louis. Concerning the operation of a water-spray filter for purifying the dirt-laden air. 1600 w. Eng Rec—Feb. 18, 1905. No. 67848.

The Science of Ventilation. J. D. Sutcliffe. Read before the Inst. of Heat. & Ven. Engrs., England. A comparison of the advantages and limits of natural and mechanical systems. Ills. 7500 w. Plumb & Dec—Feb. 1, 1905. No. 67776 A.

HYDRAULICS.

Air Lift.

Progress in the Applications of the Air-Lift Pump (Fortschritte im Bau von Mammut Pumpen). H. Steen. An illustrated description of recent installations of the "Mammut" system of air lift pumping for deep mine work in Germany. 3000 w. Glasers Annalen—Jan. 15, 1905. No. 67927 D.

Impulse Wheels.

The Governing of Impulse Wheels. Irving P. Church. Discussion suggested by a recent paper in *Engineering*, by Prof. Goodman upon the rise of pressure in a long pipe when the size of the jet is reduced to govern wheels of the Pelton type. 2000 w. Eng Rec—Feb. 25, 1905. No. 68039.

Pumping Engines.

Waterworks Pumping Engines in the United States and Canada. John Barr. Brief descriptions, with illustrations, of twelve stations visited, with general remarks. 4000 w. Inst of Mech Engrs—Jan. 20, 1905. No. 67572 D.

Stave Pipe.

Some Applications of Wooden Stave Pipe. John Birkinbine. Especially describes the construction of a line of wooden stave pipe six and one-half miles in length, along the Little Conemaugh River, near Johnstown, Penn., referring also to other work. Ills. Also discussion. 4200 w. Pro Engrs' Club of Phila—Jan., 1905. No. 68004 D.

Turbines.

The Classification of Turbines (Klassifikation von Turbinen). N. Baashuus. Deriving characteristic curves from which the turbine best adapted to the conditions of fall, speed, etc., may be determined. 1800 w. Zeitschr d Ver Deutscher Ing—Jan. 21, 1905. No. 67903 D.

MACHINE WORKS AND FOUNDRIES.

American Shops.

Some Impressions of American Workshops. A. J. Gimson. General impressions only. 1000 w. Inst of Mech Engrs—Jan. 20, 1905. No. 67571 D.

Arsenal.

The United States Arsenal at Rock Island. F. A. Stanley. Briefly outlines the history of the island and begins an illustrated description of the shops, their equipment, power plant, &c. 3500 w. Am Mach—Vol. 28, No. 5. No. 67599.

Chains.

Roller Chain Power Transmission and Construction of Sprockets. A. Eugene Michel. Information in regard to recent roller chains and the pitch line clearances of their sprockets. Ills. 2000 w. Mach, N. Y.—Feb., 1905. No. 67546 C.

Cores.

Core Sand Binders. J. S. Robeson. Read before the Pittsburgh Found. Assn. Setting forth the claims of gluetrin, discussing difference in sand structure, solid and liquid binders, &c. 4500 w. Ir Age—Feb. 9, 1905. No. 67702.

Cost Keeping.

See Industrial Economy.

Drying.

The Lochner Drying Apparatus (Das Lochnersche Trocknungsverfahren). O. Wedemeyer. Describing an apparatus for drying moulds by utilizing the heat from cooling castings. 1800 w. Stahl u Eisen—Jan. 15, 1905. No. 67935 D.

Electric Driving.

The Motor Equipment of Existing Machine Tools. George T. Hanchett. An illustrated article giving hints on selection of motors, connections, and cases of individual drive and geared connections. 2500 w. Am Elect'n—Feb., 1905. No. 67613.

See also Electrical Engineering, Motors.

Eye-Bars.

Comparisons of Full-Sized and Specimen Tests of Very Large Steel Eye-Bars. Gives a series of camparison tests made within the last few months, with remarks and conclusions. 800 w. Eng News—Feb. 2, 1905. No. 67631.

Flanging.

The Lovekin Pipe Flanging Machine. Illustrated description of the largest machine for expanding and flanging iron, steel, or other metal pipes into flanges of the lightest possible construction. 2500 w. Ir Age—Feb. 16, 1905. No. 67799.

Foundry.

Foundry of the Allis-Chalmers Co.,

We supply copies of these articles. See page 159.

Scranton, Pa. An illustrated description of changes made in remodeling an old plant, showing the improvements. 1000 w. Foundry—Feb., 1905. No. 67590.

Foundry Crane.

100-Ton Ladle Crane. Illustrates and describes a high powered overhead electric ladle crane built for the Ebbro Vale Steel Works. 1600 w. Engr, Lond—Feb. 10, 1905. No. 67881 A.

Grinding Wheels.

Emery Wheel "Dressers" and Grinding Wheel "Truing." Discusses points in the making of grinding wheels, and the necessity of using the diamond to make a perfect face. 900 w. Am Mach—Vol. 29, No. 5. No. 67600.

Iron Works.

American Iron Works (Amerikanische Eisenhütten). Max Kirdorf. A general description of American works and methods as observed by the writer during a recent tour. 5000 w. Zeitschr d Ver Deutscher Ing—Jan. 21, 1905. No. 67904 D.

Jigs.

Getting the Full Value Out of Jigs. J. F. Mirrielees. Suggestions for the use and care of jigs, outlining a working system. 1200 w. Mach, N. Y.—Feb., 1905. No. 67548 C.

Keys.

Key Design. Robert S. Riley. Discusses methods for proportioning keys in shafts. 1700 w. Am Mach—Vol. 28, No. 8. No. 68019.

Machine Tools.

Big Machine Tools. Joseph Horner. Discusses the leading problems and aspects of the big machine tools. Ills. 4000 w. Cassier's Mag—Jan., 1905. No. 67584 B.

Molding.

Molding a Sheave With Sweep and Cores. R. H. Palmer. Illustrates the appliances and describes the method. 600 w. Am Mach—Vol. 28, No. 7. No. 67801.

Molding in Cores. Vincent Colajezzi. An illustrated article giving examples showing that molds composed of dry sand cores can be constructed frequently cheaper and better than is possible with green sand molds. 1200 w. Foundry—Feb., 1905. No. 67593.

Patterns.

Pattern-Making Metals. H. Malone. in *Pattern Maker.* On the making and care of metal patterns. 2000 w. Mech Engr—Feb. 11, 1905. No. 67869 A.

Pattern Making. R. Watson. Abstract of paper read before the Rugby Engng. Soc. Suggestions of value, especially with regard to the protection of large patterns in the foundry. 4500 w. Elect'n, Lond—Feb. 10, 1905. No. 67876 A.

The Patternmaker from a Molder's Point of View. William S. McQuillam. Read before the N. Y. Found. Foremen's Assn. Discusses troubles with patterns, and the remedies for some of the defects. 1600 w. Foundry—Feb., 1905. No. 67594.

Planing Machines.

Some Features in the Design and Construction of American Planing Machines. Archibald Kenrick, Jun. Remarks are largely confined to the methods observed in a Cincinnati shop. 1500 w. Ills. Inst of Mech Engrs—Jan. 20, 1905. No. 67573 D.

Screw Cutting.

Thread Tools and Gages. A. Norman. The present article discusses hobs and chasers and their manufacture. Ills. 1500 w. Am Mach—Vol. 28, No. 6. Serial. 1st part. No. 67703.

Shop Organization.

Notes on Engineering Workshop Organization. R. Douglas T. Heap. Read before the Junior Engng. Soc., Swindon. States the leading requirements for the conduct of works, and illustrates by forms and cards for a stated purpose, explaining system. 2500 w. Engng—Feb. 17, 1905. Serial. 1st part. No. 68056 A.

Specialization.

Specialization in Manufacture. Alexander E. Outerbridge, Jr. Gives illustrations showing the advantage of quantity manufacture and undivided attention to a specialty. 1800 w. Am Gas Lgt Jour—Feb. 13, 1905. No. 67756.

Steel-Tired Wheels.

A Typical Shop Equipment for Handling Steel-Tired Wheels. Illustrates and describes the arrangement of equipment and facilities in a model wheel plant of the New York, New Haven & Hartford Railroad at Readville. 1500 w. St Ry Jour—Feb. 4, 1905. No. 67649 C.

Stores.

The Stores-Room Methods of the Pond Machine-Tool Works. H. L. Arnold. With numerous illustrations of the store-keeping departments of a large machine-shop, and copies of forms and records. 4000 w. Engineering Magazine—March, 1905. No. 67973 B.

MATERIALS OF CONSTRUCTION.

Alloys.

Some Hints on Metal Melting and Alloying. Walter J. May. Considers points which affect the condition of the metal, and the treatment necessary to secure sound castings. 2300 w. Prac Engr—Jan. 27, 1905. Serial. 1st part. No. 67675 A.

We supply copies of these articles. See page 159.

Fire Brick.

The Manufacture of Refractory Materials (Ueber die Fabrikation Feuerfester Produkte). H. Huffinger. With plans and sections of a typical manufacturing plant, and description of the manufacture of fire brick, clay retorts, and refractory products generally. 1800 w. Glückauf—Feb. 4, 1905. No. 67944 D.

Fire-Clays.

The Fire-Clays of Missouri. H. A. Wheeler. Remarks on the importance of the clay industry in the United States, with information concerning the Missouri fire-clays. 5000 w. Am Inst of Min Engrs—Jan., 1905. No. 67577 C.

Fragility.

The Fremont Method of Determining the Fragility of Iron and Steel. Thorsten Y. Olsen. An explanation of the Fremont method and machine. Ills. 3800 w. Pro Engrs' Club of Phila—Jan., 1905. No. 68007 D.

Impact Tests.

Impact Tests in Detail. E. P. Buffet. Condensed translation of a paper by M. A. Pérot, describing an interesting investigation. Ills. 1000 w. Am Mach—Vol. 28, No. 8. No. 68018.

Muntz's Metal.

Mass Analysis of Muntz's Metal by Electrolysis. John G. A. Rhodin. From a paper before the Faraday Society. Describes a method devised for accurately determining the copper contents of Muntz's metal at a speed allowing the use of the results in the course of manufacture. Ills. 2500 w. Elect'n, Lond—Feb. 10, 1905. No. 67875 A.

Steel.

Steel as an Engineering Material. William Stuart Standiford. Considers steel as a material, its manufacture and the effect of different methods of treatment, the uses to which it has been applied, &c. 2000 w. Min Wld—Feb. 11, 1905. No. 67754.

The Influence of Carbon, Phosphorus, Manganese, and Sulphur upon the Strength of Open-Hearth Steel (Ueber den Einfluss von Kohlenstoff, Phosphor, Mangan, und Schwefel auf die Bruchfestigkeit des Martinstahls). A review of Campbell's formulas for determining the strength of steel from its composition. Serial. Part I. 4500 w. Stahl u Eisen—Jan. 15, 1905. No. 67934 D.

Stress Testing.

Alternating Stress Testing-Machine at the National Physical Laboratory. T. E. Stanton. An illustrated description of a machine recently fitted and erected in the workshop of the department. 4000 w. Engng—Feb. 17, 1905. No. 68051 A.

Thermit.

Aluminothermics. An illustrated article describing what thermit is, the applications made of it, and the things to be observed to secure success. 1600 w. Foundry—Feb., 1905. No. 67591.

MEASUREMENT.

Calorimeter.

The Junker Gas Calorimeter in Practice. Carl F. Dietz. Describes the apparatus for determining the calorific value of gases and a test made with it. Discussing the results, adaptability, &c. Ills. 3000 w. Stevens Ind—Jan., 1905. No. 67726 D.

High Temperatures.

On the Measuring of High Temperatures in Connection with Metallurgical Work. Dr. Alfred Gradenwitz. Considers some of the fields of application of pyrometers. Ills. 1200 w. Min Rept—Feb. 9, 1905. No. 67757.

Thermometers and Pyrometers, with Some of Their Industrial Applications. Robert S. Whipple. Read before the Cleveland Inst. of Engrs. Gives a summary of the various means of measuring temperature in general use, and discusses details and applications. 5000 w. Engng—Feb. 17, 1903. No. 68055 A.

Pendulum.

An Electric Pendulum with Free Escapement (Pendule Electrique à Echappement Libre). Ch. Féry. The solenoid action of the magnet pendulum-bob is regulated by the pendulum itself, which also acts as a motor to drive the escapement wheel. 800 w. Comptes Rendus—Jan. 23, 1905. No. 67921 D.

Speedometer.

The Krauss Speedometer. Illustrated description of a tachometer especially designed for automobiles. 1500 w. Sci Am Sup—Feb. 18, 1905. No. 67811.

POWER AND TRANSMISSION.

Compressed Air.

Experiments with High-Speed Compressors (Versuche mit Raschlaufenden Kompressoren). A. Lebrecht. Data and results of tests upon balanced compressors adapted for direct connection to electric motors, and operating at rotative speeds of 800 to 1,200 revolutions per minute. Serial. Part I. 3000 w. Zeitschr d Ver Deutscher Ing—Feb. 4, 1905. No. 67908 D.

The Central Compressed-Air Power Plant of the St. Louis Terminal Station. A description of the extensive Ingersoll-Sergeant plant used for the signal system, for charging brake reservoirs, and for

general power purposes at the Union Terminal at St. Louis. 2000 w. Compressed Air—Feb., 1905. No. 67977.

Valve Gears of Compressed-Air Rock Drills. C. Weidmann, in *Glückauf*. An illustrated study of the action of valve gears in rock drills. 2000 w. Quarry—Feb., 1905. No. 67775 A.

Conveyors.

Improved Conveyor Systems and Appliances (Neuere Konveyor-Systeme und Anlagen). M. Buhle. Illustrating and describing the coal conveying systems of Hunt, of Bradley, and others as used in Germany. 1800 w. 1 plate. Glückauf—Feb. 11, 1905. No. 67945 D.

Improved Pipe and Mixer System for Water Conveyors (Neue Konstruktionen für die Anlage von Rohrleitungen und Mischtrichtern beim Spülversatzverfahren). Details of pipes, connections, hoppers, etc., for use in conveying ashes and débris by water. 1200 w. Glückauf—Feb. 11, 1905. No. 67946 D.

The Waste Conveying Plant of the Schedewitz Coal Company at Zwickau, in Saxony (Das Spülversatzverfahren beim Erzgebirgischen Steinkohlen-Aktienverein in Schedewitz bei Zwickau in Sachsen). H. Jobst. Illustrating and describing the use of conveyor bands and water jets for carrying débris, ashes, etc. Two articles. 6000 w. Glückauf—Jan. 28, Feb. 4, 1905. No. 67942 each D.

Cranes.

A Gigantic Electric Shipyard Crane. Dr. Alfred Gradenwitz. Illustration of the powerful electric crane recently erected at Lloyd's arsenal in Trieste, with description. 900 w. Sci Am Sup—Feb. 11, 1905. No. 67714.

Notes on Cranes—The Wellman Furnace Charging Machine. A. D. Williams. Illustrates and describes types of Wellman machines. 800 w. Am Mach—Vol. 28, No. 5. No. 67601.

Special Forms of Cranes. Joseph Horner. Illustrates and describes recent types for special demands. 3000 w. Cassier's Mag—Feb., 1905. Serial. 1st part. No. 67668 B.

Recent Cranes (Neuere Krane). A. Müller. Illustrating and describing some recent, electrically-driven travelling cranes for machine shops and iron works. 3000 w. Zeitschr d Ver Deutscher Ing—Feb. 11, 1905. No. 67911 D.

See also Civil Engineering, Waterways and Harbors.

Gear Teeth.

The Strength of Gear Teeth Sustaining Shock. Gives tables showing values of safe tooth loads calculated from the original Lewis formula, and also from the reduced Lewis formula. 2000 w. Am Mach—Vol. 28, No. 7. No. 67802.

Tooth Form and Velocity Ratio in Gear Wheels (Genauigkeitsgrad und Geschwindigkeitsverhältnis bei Verzahnungen). W. Hartmann. Showing the advantage of the involute form of tooth, and demonstrating the variation in velocity-ratio produced by a change in the form of curve. 2000 w. Zeitschr d Ver Deutscher Ing—Feb. 4, 1905. No. 67909 D.

STEAM ENGINEERING.

Boiler Explosion.

Boiler Explosion on the New York Central. George L. Fowler. An illustrated account of an explosion which derailed and wrecked another passing train. 2000 w. R R Gaz—Vol. XXXVIII, No. 7. No. 67833.

Boiler Inspection.

New Official Requirements for Steam-Boiler Installation (Neue Allgemeine Polizeiliche Bestimmungen über die Anlegung von Dampfkesseln). C. Bach. A review of boiler explosions in Germany, and a discussion of the new regulations framed by a commission of engineers. 3500 w. Zeitschr d Ver Deutscher Ing—Jan. 28, 1905. No. 67905 D.

Boilers.

A Comparison of Vertical and Horizontal Tubes in Water-Tube Boilers. W. R. Cummins. Reviews the conditions necessary to make a commercially successful boiler, favoring the vertical tube. Discussion. 16 plates. 10000 w. Trans N-E Coast Inst of Engrs & Shipbuilders—Jan., 1905. No. 67825 E.

Circulation of Water in Steam Boilers. Egbert P. Watson. Considers the evils of poor circulation; the natural, artificial and forced circulation, &c. 2500 w. Cassier's Mag—Jan., 1905. No. 67588 B.

Central Stations.

A Study for a Central Power and Heating Plant at Washington. Extracts from the interesting report of Bernard R. Green, assisted by Prof. S. Homer Woodbridge, in regard to the investigations made to determine the advisability of erecting a station for the group of Federal executive buildings in the vicinity of the Mall. 5400 w. Eng Rec—Feb. 11, 1905. No. 67772.

Economies Obtainable by Various Uses of Steam in a Combined Power and Heating Plant. A discussion of economies obtainable at the isolated plant in Washington, reported by B. R. Green and S. Homer Woodbridge. Critical review. 4000 w. Eng Rec—Feb. 18, 1905. No. 67852.

We supply copies of these articles. See page 159.

Combustion.

Combustion. C. C. Major. Analytical study of the chemical and thermal changes in the combustion of fuels, deriving formulas for the computation of the mechanical energy evolved. 5500 w. Power—Feb., 1905. No. 67564 C.

Engine Economy.

The Best Economy of the Piston Steam Engine at the Advent of the Steam Turbine. Prof. J. E. Denton. Read before the Mech. Sec. of the Int. Cong. of Arts and Sciences. Traces the development of economy in marine and stationary engines, comparing the economy of the piston engine and the steam turbine, &c. 5500 w. Eng Rec—Feb. 25, 1905. No. 68037.

Engines.

A Large Rolling Mill Engine. Illustrated description of an engine in use at the great Hungarian State Steel Works of Diósgyör, near Miskole. 500 w. Engr, Lond—Feb. 3, 1905. No. 67789 A.

Engines at the Power Stations, and at the St. Louis Exhibition. Alfred Saxon. Notes on two of the large power stations in New York, and on the engines exhibited at St. Louis. Ills. 2000 w. Inst of Mech Engrs—Jan. 20, 1905. No. 67574 D.

Expansion Joints.

Compensating Pipe Connections (Kompensationsrohre). H. Still. Describing various forms of connections to provide for the expansion and contraction of long lines of pipe. 1800 w. Glückauf—Jan. 14, 1905. No. 67939 D.

Feed Water Heaters.

Location of Feed-Water Heaters and Feed Pipes. W. H. Wakeman. Describes arrangements of piping for feed-water heaters, giving diagrams. 1300 w. Engr, U. S. A.—Feb. 15, 1905. No. 67837 C.

Fuel Economy.

Fuel Economy in Steam Power Plants. William H. Booth and John B. C. Kershaw. Considers the analysis and treatment of feed-water, the sampling and testing of fuel, air supply, types of boilers and furnaces, steam superheating and condensation, waste gases, draught, &c. Ills. 12800 w. Inst of Elec Engrs (England)—Jan. 12, 1905. No. 67686 D.

Indicating.

Indicating Westinghouse Engines. H. L. Strong. Describes method. 1500 w. Power—Feb., 1905. No. 67567 C.

Indicator Connections. J. W. Parker. Explains some arrangements tried, and the results. Ills. 800 w. Power—Feb., 1905. No. 67565 C.

The Application of the Indicator to Rotary Engines. W. Pollard Digby. Describes the circumstances under which indicator cards were taken on certain rotary engines, and what they show. 2500 w. Engr, Lond—Jan. 27, 1905. No. 67691 A.

Manholes.

Boiler Manholes and Handholes. R. T Strohm. Considers the location, size, reinforcing rings, covers, &c. Ills. 2000 w. Am Elect'n—Feb., 1905. No. 67612.

Oil.

Oil as a Fuel. Describes methods of burning, especially the injectors for breaking up the stream of oil, setting forth the claims of the Lucal system. 2200 w. Ir & Coal Trds Rev—Jan. 27, 1905. No. 67698 A.

Power Plant.

The Steam-Power Plant of the Hanover Electric Station (Die Dampfmaschinenanlage des Drehstromwerkes der Stadt Hannover). Gustav ter Meer. With plan of the engine room, details of the machinery, and data and results of tests of engines and boilers. 4000 w. Zeitschr d Ver Deutscher Ing—Jan. 21, 1905. No. 67901 D.

Reheaters.

On the Economy of Reheaters. Ernest R. Briggs. An examination of the principal reheater cycles in use on various engines. 2500 w. Engr, Lond—Feb. 10, 1905. No. 67880 A.

Steam Turbines.

A Comparison of Steam Turbines. R. M. Neilson. Read before the Manchester Assn. of Engrs. An illustrated article explaining the working of the various types of turbines for the purpose of comparison. 3800 w. Mech Engr—Jan. 21, 1905. Serial. 1st part. No. 67539 A.

Low-Pressure Steam Turbines for Mine Purposes. George E. Walsh. Describes an improved type of low-pressure steam turbine, and its application to mining operations. 2200 w. Min Wld—Jan. 28, 1905. No. 67545.

Making a Small Curtis Turbine. H. J Travis. Drawings and description of constructional details, discussing operative results, losses, bucket speeds, power available, and economy. 3700 w. Power—Feb., 1905. No. 67566 C.

Notes on Steam Turbines. Frederick C. Bates. Read at meeting of the Engine Builders' Assn. Briefly reviews the history of the turbine, explaining the principle and describing modern types. 2200 w. Ir Trd Rev—Feb. 23, 1905. No. 68012.

Power Required for Condensing Auxiliaries in a Steam Turbine Plant. J. R. Bibbins. Gives results of tests made, describing methods of observation and calculation. 2200 w. Power—Feb., 1905. No. 67568 C.

We supply copies of these articles. See page 159.

The Hamilton-Holzwarth Steam Turbine (Die Hamilton-Holzwarth Dampfturbine). A. Bantlin. A full detailed description of the Holzwarth steam turbine. as built at Hamilton, Ohio, and exhibited at St. Louis. 3500 w. Zeitschr d Ver Deutscher Ing—Jan. 28, 1905. No. 67906 D.

The Lindmark Steam Turbine. An illustrated explanation of the features of this turbine as given in the patent records, explaining the purpose of the invention, its action, &c. 1300 w. Mach, N. Y.—Feb., 1905. No. 67549 C.

The Steam Turbine. F. G. Gasche. Abstract of a paper presented before the Steel Works Club of Joliet, Ill. A review of the development of types of turbines. and remarks on the advantages over the reciprocating engine. Ills. 2500 w. Engr, U. S. A.—Feb. 15, 1905. No. 67839 C.

Superheating.

Efficiency Tests of the Wolf Superheated Steam Portable Engine (Leistungsversuche an Wolfschen Heissdampf-Locomobilen). M. F. Gutermuth. Data and results of tests with superheating up to 140° C., showing a result of 9¼ pounds of steam per horse-power hour. 4000 w. Zeitschr d Ver Deutscher Ing—Feb. 11, 1905. No. 67910 D.

The Specific Heat of Superheated Steam. The present article reviews the paper of Prof. Sidney A. Reeve, which was published in the Worcester Polytechnic Journal. 2500 w. Engr, Lond—Feb. 3, 1905. Serial. 1st part. No. 67787 A.

The Superheating of Steam and Its Influence on Engine Economy. R. Neilson. The first of two articles; including a description of the various modes of giving additional heat to the steam, with typical forms of superheater construction. 4000 w. Engineering Magazine—March, 1905. No. 67972 B.

Tests.

Test of the Power Plant of the Cambridge Electric Light Company. Lionel S. Marks. Gives results of tests made for determining whether the guarantees of the steam engine builders were fulfilled. Ills. 3500 w. Harvard Engng Jour—Jan., 1905. No. 67597 C.

MINING AND METALLURGY

COAL AND COKE.

Anthracite.

The Anthracite Situation in Colorado. A. Lakes. Information in regard to the location, occurrences and quality. 1200 w. Min Rept—Jan. 26, 1905. No. 67551.

Virginia Anthracite Coal. L. S. Randolph. Information concerning these deposits. the character of the coal, recent development, &c. Ills. 3300 w. Cassier's Mag—Feb., 1905. No. 67669 B.

Belgium.

Black Band Deposits in the Campine Coalfield. B. Schulz-Briesen. Concerning the deposits of black band iron ore in association with the coal, and the indication of a co-relation between this Belgian field and those of Dudley and Cleveland in England. Map. 1200 w. Ir & Coal Trds Rev—Jan. 27, 1905. No. 67697 A.

Borings in the Coal and Iron Districts of Northern Belgium (Bohraufschlüsse von Kohlen und Blackband Lagerstätten im Nordbelgischen Kohlenbecken der Campine). B. Schulz-Briesen. With sections of the strata, and map showing the relation of the deposits to those of England and Germany. 2500 w. Glückauf—Jan. 14, 1905. No. 67937 D.

Canada.

The Blairmore-Frank Coal Field, Alberta, Canada. E. Jacobs. A description of a comparatively new coal field that is being rapidly opened. Ills. 4000 w. Mines & Min—Feb., 1905. No. 67639 C.

Carboniferous Flora.

Carboniferous Flora of Britain. John Pringle. Read before the N. Wales branch of the Nat. Assn. of Colliery Engrs. Reviews the geology of Britain and gives information of interest concerning the coal plants. 5500 w. Aust Min Stand—Dec. 29. 1904. No. 67815 B.

Coal Boring.

Pneumatic Coal-Boring Machines and Tools. W. Lynch. Read before the S. Staffordshire and E. Worcestershire Inst. of Min. Engrs. (Abstract.) Briefly describes some of the tools and their operations. General discussion follows. Ill. 2500 w. Col Guard—Feb. 17, 1905. No. 68050 A.

Coal Cutting.

Tests of a Coal Cutting Machine (Versuche mit einer Schrämmaschine mit Drehendem Schrämwerkzeug). Giving the time required to cut various areas, with a revolving spindle cutter driven by

We supply copies of these articles. See page 159.

compressed air motor. 800 w. Glückauf —Jan. 28, 1905. No. 67943 D.

Coal Supplies.

Final Report of the Royal Commission on Coal Supplies, 1905. 13500 w. Col Guard—Jan. 27, 1905. (Supplement.) No. 67687 A.

Coal Testing.

The Fuel-Testing Plant at St. Louis. From a recent report of the U. S. Geol. Survey. A description of this exhibit, describing the plant and tests made, and giving related information. 5400 w. Ir Trd Rev—Feb. 16, 1905. No. 67816.

Coke.

By-Product Coke as Made by the Coke Oven Plant of the Otto-Hoffman and United-Otto Types, Camden, N. J. Edwin A. Moore. Read before the Philadelphia Found. Assn. Describes the method of manufacturing coke and the recovery of the by-products from the coal by means of the Otto-Hoffman system. 8700 w. Ir Trd Rev—Feb. 9, 1905. No. 67739.

Lamp-Black Oil Coke. Robert Schorr. Gives information in regard to the use made of lamp-black by the California Gas & Electric Corporation, at Oakland. 900 w. Eng & Min Jour—Feb. 16, 1905. No. 67821.

Coke Ovens.

The Collin Coke Oven (Koksöfen Bauart Collin). Fr. Frölich. Giving sectional details of continuous ovens arranged for recovery of by-products, either with or without regenerators. 2000 w. Zeitschr d Ver Deutscher Ing—Jan. 21, 1905. No. 67902 D.

Colorado.

The Geology and Coal Deposits of the Spanish Peaks' District. A. Lakes. Illustrated description of these Southern coal fields of Colorado. 1500 w. Min Rept—Feb. 16, 1905. No. 67854.

Deep Mines.

Problems of Thick Coal Workings in Deep Mines. Lawrence Holland. Read before the S. Staffordshire & E. Worcestershire Inst. of Min. Engrs. Describes conditions in mines 3,483 ft. in depth, offering suggestions for working. General discussion follows. 4000 w. Col Guard —Jan. 27, 1905. No. 67688 A.

Missouri.

The Coal-Fields of Missouri. B. F. Bush. A description of these fields, with map, an account of the methods of mining and character of the coals. 4800 w. Am Inst of Min Engrs—Jan., 1905. No. 67604.

Peat.

New Method of Treating Peat. A brief description of the Stauber method. 1000 w. Sci Am Sup—Feb. 18, 1905: No. 67810.

The Peat Industry. Arthur P. Hall and Richard C. Tolman. Describes briefly the methods of preparing peat for market, and states what has been accomplished in other countries. 1600 w. Eng & Min Jour—Feb. 9, 1905. No. 67745.

Tipples.

Coal Mine Tipples. H. G. Tyrrell. Illustrates and describes two designs of steel coal tipples such as are generally used in West Virginia. 500 w. Eng & Min Jour—Feb. 2, 1905. No. 67608.

Waste Heat.

The Utilization of Waste Heat from Coke Ovens. Considers the heat available and methods and apparatus best suited for using it for the generation of steam. 2500 w. Mines & Min—Feb., 1905. No. 67636 C.

COPPER.

Butte.

The Butte Copper Interests. Dwight E. Woodbridge. A description of the district's mines and smelters. Ills. 3500 w. Ir Age—Feb. 16, 1905. No. 67800.

Spain.

Rio Tinto. J. W. Gregory. Abstract from proceedings of the Australasian Inst. of Min. Engrs. An illustrated article describing the geology and ores. The chief types of ore are the copper-bearing iron pyrite, and cupriferous schist. The ore contains 20 to 25 dwt. of silver per ton and a trace of gold. 1600 w. Eng & Min Jour—Feb. 23, 1905. No. 68022.

South Africa.

The Copper Districts of Cape Colony, South Africa. Walter Harvey Weed. Map and description of the copper-producing district, the ore, occurrence, &c. 1000 w. Eng & Min Jour—Feb. 9, 1905. No. 67746.

GOLD AND SILVER.

Assaying.

Crude Oil for Fire Assaying. F. C Bowman. Abstract of a paper read before the Colorado Sci. Soc. An account of experiments with crude oil, and the cost. 600 w. Eng & Min Jour—Feb. 2, 1905. No. 67606.

Australia.

Castlemaine Goldfield. E. J. Dunn. Report of recent investigations of this field. 1600 w. Aust Min Stand—Dec. 22, 1904. No. 67540 B.

Comstock.

Unwatering the Comstock Lode. An account of the numerous efforts made to unwater and explore the entire Comstock

lode, the degree of success, and an illustration of the electric pumps recently installed. 3200 w. Min & Sci Pr—Feb. 4, 1905. No. 67760.

Cripple Creek.

The Mines of Cripple Creek, Colo. Information from the recently issued bulletin No. 254, by Lindgren and Ransome of the U. S. Geol. Survey. 2800 w. Min & Sci Pr—Jan. 21, 1905. Serial. 1st part. No. 67557.

Cyanide.

Filling and Emptying Cyanide Vats by Machinery. An illustrated description of the Blaisdell automatic tank emptying system as installed in South Africa. 800 w. Min Rept—Feb. 2, 1905. No. 67640.

Some Further Improvements in Appliances for the Cyanide Clean-Up. D. V. Burnett. Describes the process as adopted at the present time on the Crown Deep, Ltd. Ills. 1500 w. Jour Chem, Met, & Min Soc of S Africa—Dec., 1904. No. 67671 E.

The Use of Mercury Chloride in Testing Cyanide Solutions. Leonard M. Green. A report of investigations of the reactions of mercuric chloride on copper double cyanides and, incidentally, on zinc double cyanides. 1000 w. Min & Sci Pr—Jan. 28, 1905. No. 67642.

Mexico.

The Gold-Mines of the San Pedro District, Cerro de San Pedro, State of San Luis Potosi, Mexico. George A. Laird. Briefly reviews the history of the district, describing the geology, ores, mines, methods of mining, source and distribution of the ores. Map. 7200 w. Am Inst of Min Engrs—Jan., 1905. No. 67575 D.

Nevada.

The Goldfields District, Nevada. A description of this district, as given by J. E. Spurr of the U. S. Geol. Survey. 2000 w. Sci Am Sup—Feb. 18, 1905. No. 67812.

Tonopah and Goldfield, and Their Rapid Development. An illustrated account of these new mining districts of Southern Nevada. 1500 w. Min & Sci Pr—Feb. 11, 1905. No. 67858.

New Zealand.

The Hauraki Goldfields, New Zealand. Waldemar Lindgren. An illustrated account of this interesting gold-mining region and its development. 2500 w. Eng & Min Jour—Feb. 2, 1905. No. 67605.

Placer Gold.

Source of the Placer Gold in Alder Gulch, Montana. Earl Douglass. Explains evidences that indicate that it was from adjacent lodes. 3500 w. Mines & Min—Feb., 1905. No. 67638 C.

Rhodesia.

Gold Mining in Rhodesia. F. C. Roberts. The present number gives an illustrated description of the country, its geology and ancient workings. 1200 w. Min & Sci Pr—Feb. 4, 1905. Serial. 1st part. No. 67759.

Smelting.

Chloro-Electrolytic Smelting. Abstract of a paper by Prof. W. Morley Cobeldick, read before the Chemical Society of London, which discussed the application of the Swinburne-Ashcroft process to the treatment of Broken Hill ore. 4000 w. Elec-Chem & Met Ind—Feb., 1905. No. 67621 C.

Spain.

Gold Mining in the Ancient Roman Workings in Spain. Alexander Del Mar. An account of the placers of Las Medulas describing the manner in which the ancients used advanced methods of hydraulic engineering in gold mining. 4000 w. Engineering Magazine—March, 1905. No. 67975 B.

Telluride Ores.

The Existence of Telluride Ores in the Hauraki Goldfields. Notes on the metallurgical practice and costs of treatment of ores and sands at Kalgoorlie. 1300 w. N Z Mines Rec—Dec. 16, 1904. No. 67527 B.

Transvaal.

The Transvaal Mining Industry in 1904. A report of a very successful year. 3000 w. Engr, Lond—Feb. 3, 1905. No. 67790 A.

Washing.

The Washing of Goldbearing Gravel in Sluices (Die Verwaschung Goldhaltiger Gerölle in Gerinne). L. St. Ranier. A discussion of the influence of the size of pebbles and the velocity of the water flow upon the separation of the gold. Two articles. 5000 w. Oesterr Zeitschr f Berg u Hüttenwesen—Feb. 4, 11, 1905. No. 67950 each D.

IRON AND STEEL.

Alabama.

Iron Mining in the Birmingham District, Alabama. W. R. Crane. An illustrated article describing the deposits, methods of mining, ore handling, haulage, &c. 3300 w. Eng & Min Jour—Feb. 9, 1905. No. 67747.

Blast Furnaces.

Fundamental Principles Involved in Blast Furnace Practice. Edward A. Uehling. Considers the raw materials used, the preparation of the ores, fuel, charging, &c. 9500 w. Jour Fr Inst—Feb., 1905. No. 67724 D.

We supply copies of these articles. See page 159.

Colorado.

Colorado Iron Ore Deposits. James Angus Snedaker. On the iron ore resources of this State, suitable for steel manufacturing. 1000 w Eng & Min Jour—Feb. 16, 1905. No. 67818.

Dry Blast.

Is it Advantageous to Dry the Air for Blast Furnaces? (Ist es Vorteilhaft den Hochöfengebläsewind zu Trocknen?) Bernhard Osann. An examination of the Gayley dry-air blast system, maintaining that the possible gain is overbalanced by the additional cost. 5000 w. Stahl u Eisen—Jan. 15, 1905. No. 67933 D.

The Application of the Dry-Air Process to Blast Furnaces (Die Verwendung von Trockenem Gebläsewind in Hochofenbetriebe). An account of the Gayley dry-air blast system emphasizing the advantages of independence of meteorological conditions and changes. 1200 w. Oesterr Zeitsch f Berg u Hüttenwesen—Jan. 21, 1905. No. 67948 D.

The Gayley Dry Air Blast. Brief reports of some of the theories advan ed to account for the facts givin in paper by James Gayley. 2500 w. Ir Age—Feb. 9, 1905. No. 67701.

Electric Smelting.

See Electrical Engineering, Electrochemistry.

Iron District.

Animikie, or Loon Lake, Iron-Bearing District. W. N. Smith. Information concerning recent work in this district of Ontario. Map. 3500 w. Min Wld—Feb. 18, 1905. No. 67857.

Manganese.

Sulphides and Silicates of Manganese in Steel. J. E. Stead. A detailed description of experimental investigations. Ills. 2200 w. Ir & St Mag—Feb., 1905. No. 67721 D.

Solidification.

The Increase in Volume of Liquid Iron, Saturated with Carbon in the Electric Furnace, at the Moment of Solidification (Sur l'Augmentation de Volume de la Fonte Liquide, Saturée de Carbone au Four Electrique au Moment de la Solidification). Henri Moissan. Data and results in connection with the artificial production of diamonds, showing that iron of small carbon content contracts, and with large carbon content expands, on solidification. 2500 w. Comptes Rendus—Jan. 23, 1905. No. 67918 D.

MINING.

Conveyors.

See Mechanical Engineering, Power and Transmission.

Cost.

The Cost of Mining. W. R. Ingalls. A general consideration of the comparative cost of mining, stating the conditions which determine the results. 2600 w. Eng & Min Jour—Feb. 16, 1905. No. 67820.

Deep Leads.

The Deep Leads of Victoria. Waldemar Lindgren. An illustrated description of the conditions, and of the methods of mining. 2200 w. Eng & Min Jour—Feb. 16, 1905. No. 67819.

Electric Blasting.

Many Advantages of Blasting by Electricity. George A. Allen. An illustrated article explaining the usual way of arranging the blast and connecting the wires, and giving information in regard to fuses, the blasting machine, &c. 3800 w. Min Wld—Feb. 11, 1905. No. 67753.

Electric Power.

A Model Electric Mining Plant. H. A. Pharo. Illustrates and describes an electric plant for driving mining and milling machinery near Silver City, Idaho. The first high-tension transmission built in America by a mining company for its own use. 3000 w. Cassier's Mag—Feb., 1905. No. 67664 B.

Application of Electric Power in Collieries. G. M. Brown. Abstract of a paper read before the Rugby Engng. Soc. Considers the use of electricity in the form of direct current, and also alternating current, the applications, &c. 4000 w. Ir & Coal Trds Rev—Feb. 3, 1905. No. 67792 A.

Dangers Attending the Employment of Electricity in Mines. Abstract from *Glückauf*. An illustrated article discussing the conditions which add to the dangers of the employment of electricity, the safety devices and precautions to be used, &c. 2300 w. Ir & Coal Trds Rev—Feb. 10, 1905. No. 67884 A.

Electricity in Coal Mining. George E. Walsh. Considers the applications thus far made of electricity in the mining of coal. 1800 w. Eng & Min Jour—Feb. 2, 1905. No. 67609.

High-Tension Systems for Mining Purposes. George E. Walsh. An account of the application of electric power at Folsom Creek, Cal., and neighboring mining regions. 1400 w. Eng & Min Jour—Feb. 23, 1905. No. 68021.

Explosions.

Coal-Dust Explosions in Mines. W. H. Graves. Discusses the conditions under which they have occurred and the methods for their prevention. 3000 w. Mines & Min—Feb., 1905. No. 67637 C.

We supply copies of these articles. See page 159.

Gravel Mining.

Gravel-Mining Costs in Alaska and Northwest Canada. Chester W. Purington. Gives facts compiled from statistics collected during a recent inspection of the placer fields in Alaska, Yukon Territory, and northern British Columbia. 1600 w. Eng & Min Jour—Feb. 9, 1905. No. 67744.

Hoisting.

Hoists and Hoisting. Dennis H. Stovall. Illustrates four types of hoists, and explains the work for which they are united. 800 w. Min Rept—Feb. 2, 1905. No. 67641.

Underground Hoisting in Deep Level Mines. G. A. Denny. Describes briefly a scheme of utilizing conveyor belts for this purpose on inclines of an angle of 20 to 23 degrees. Also discussion. 11000 w. Jour S Af Assn of Engrs—Oct., 1904. No. 68026 F.

Mine Equipment.

Some Applications of Electricity in German Mines. Illustrated description of a number of installations of pumping and winding plants. 2500 w. Elect'n, Lond —Jan. 27, 1905. No. 67685 A.

Vesta No. 4 Mine of the Vesta Coal Co. at California, Pa. William L. Affelder. An illustrated detailed description of one of the finest equipped coal mines in the United States. 6500 w. Mines & Min—Feb., 1905. No. 67634 C.

Mine Fire.

The Mine Fire at Dominion No. 1 Colliery, Glace Bay, N. S. Shirley Davidson and Norman McKenzie. A description of the mine and the disaster, with illustrations and plates. 5400 w. Can Soc of Civ Engrs—Jan., 1905. No. 68000 D.

Mine Gas.

Gases in Mines. W. Poole. Lecture delivered at Charters Towers School of Arts. Considers the gases which poison the air for breathing purpose, and the necessity for efficient ventilation through the working places of mines. 3500 w. Queens Gov Min Jour—Dec. 15, 1904. No. 67595 B.

Mining Laws.

United States Mining Laws. C. W. Goodale. Abstract of a paper read before the Montana Soc. of Engrs. Gives opinions of various men of experience, and reviews briefly some of the conditions in laws of other countries, with an account of the copper trust location. 2800 w. Eng & Min Jour—Feb. 2, 1905. No. 67607.

Mining Power.

A Discussion of Systems of Power Supply for Mine Operation. F. V. Henshaw. Comparing the relative advantages of electricity and compressed air for mining work. 3000 w. Engineering Magazine—March, 1905. No. 67971 B.

Ore Handling.

Coal and Ore Handling Plant in the Island of Elba. Illustrates and describes a system of automatically-operated overhead conveyors for the blast-furnace plant at Portoferraio, to handle the ore and coal. 1600 w. Sci Am Sup—Feb. 4, 1905. No. 67661.

Ore Handling at Conneaut, Ohio. H. E. Scott. Brief illustrated description of the main features of this harbor and the system for rapidly and economically handling the ore. 3800 w. Jour Worcester Poly Inst—Jan., 1905. No. 67570 C.

Ore Treatment.

Ore Treatment in Laurium, Greece. Henry F. Collins. Brief description of the methods of a French company and a Greek company engaged in smelting the output of the ancient mines. 2000 w. Eng & Min Jour—Feb. 23, 1905. No. 68020.

Pumping.

Electric Pumping Plants. Frank C. Perkins. Illustrated description of a number of electrically driven pumping plants in Germany, England, and America. 3500 w. Mines & Min—Feb., 1905. No. 67635 C.

Records.

The Method of Keeping "Stope Books" in the Mines of the Butte District, Montana. Charles E. Morrison. An explanation, with diagrams. 2000 w. Sch of Mines Qr—Jan., 1905. No. 68011 D.

Shaft Sinking.

The Deepening of a Double Shaft at the Königsgrube Mine at Röhlinghausen in Westphalia (Das Abteufen eines Doppelschachtes der Zeche Königsgrube bei Röhlingshausen i. W.). H. Bonacker. Describing a difficult piece of shaft sinking through quicksand. 1200 w. Glückauf—Jan. 14 1905. No. 67938 D.

Tubbing.

The Question of Corrugated Tubbings (Zur Frage der Gewellten Tubbings). Prof. Heise. A discussion of the advantages of corrugated sectional linings for shafts. 2000 w. Glückauf—Jan. 21, 1905. No. 67940 D.

Underground Temperature.

Notes on Underground Temperature Observations. James Stirling. Gives the chief results of a series of observations made in some of the deep mines at Bendigo, to a depth of 3,250 ft. 1500 w. N Z Mines Rec—Dec. 16, 1904. No. 67528 B.

We supply copies of these articles. See page 159.

Winding Ropes.

Nickel-Steel Winding Ropes (Förderseildraht aus Nickelstahl). Julius Divis. A comparison of nickel steel with carbon steel for ropes for mine hoists, showing that the gain due to the superiority of the nickel steel is more than offset by the higher price. Two articles. 5000 w. Oesterr Zeitschr f Berg u Hüttenwesen—Jan. 28, Feb. 4, 1905. No. 67949 each D.

MISCELLANY.

Petroleum.

Petroleum in the Malay Islands (Das Erdöl auf den Malaiischen Inseln). Hans Höfer. A detailed account of the petroleum developments in the Dutch East Indies and in the Philippine Islands. 5 articles. 8000 w. Oesterr Zeitschr f Berg u Hüttenwesen—Jan. 14, 21, 28, Feb. 4, 11, 1905. No. 67947 each D.

Tin.

Notes on the Mount Bischoff Tin Mine, Tasmania. Sydney Fawns. Information concerning the location, geological features, deposits, method of mining, &c. 3000 w. Min Jour—Jan. 21, 1905. No. 67524 A.

Zinc.

The Zinc-Smelting Industry of the Middle West. H. C. Meister. Deals with the western group, including Illinois, Missouri, Kansas, Wisconsin, and Indiana. Discusses the methods used. 4000 w. Am Inst of Min Engrs—Jan., 1905. No. 67576.

Zinc and Lead Deposits of Northern Illinois. From a paper by H. Foster Bain, discussing the geology, topography and ore deposits. 4300 w. Min Wld—Feb. 4, 1905. No. 67617.

Zinc Industry and Smelting in the United States. Walter Renton Ingalls. Explains the different conditions in the east and west, the gas smelters, and the increased cost of natural gas, &c. Min Wld—Feb. 18, 1905. No. 67856.

RAILWAY ENGINEERING

CONDUCTING TRANSPORTATION.

Grain Carrying.

The Grain Carriers. Map, tables and interesting information concerning the grain carrying railroads in the United States. 4000 w. R R Gaz—Vol. XXXVIII, No. 8. No. 68025.

MOTIVE POWER AND EQUIPMENT.

Air-Brakes.

Arrangement of Piping and Main Reservoirs to Prevent Water in Brake System. T. L. Burton. An illustrated explanation of systems of piping in use on various roads. 1200 w. Ry & Loc Engng—Feb., 1905. No. 67581 C.

Recording Air Brake Operations. An illustrated article showing the apparatus in use by the railway department of the International Correspondence Schools of Scranton, Pa., and giving extracts from records obtained. 1400 w. Ry Age—Feb. 17, 1905. No. 67827.

Brakes.

The Mechanical Action of Wheel-Block Car Brakes. Robert H. Smith. An explanation of brake action on railway and tramway cars. 2000 w. Engr, Lond—Jan. 27, 1905. No. 67692 A.

Braking.

Device for Regulating the Braking Power of Cars. Illustrated description of a device which regulates the retarding force applied to the wheels. 1800 w. Ry Mas Mech—Feb., 1905. No. 67632.

Car Wheels.

Rolled-Steel Car Wheels. Samuel M. Vauclain. Describes and illustrates the manufacture of these wheels, discussing their superiority and the great need in these days of heavy rolling-stock of securing a safe wheel. General discussion. 3000 w. Jour Fr Inst—Feb., 1905. No. 67723 D.

Couplers.

On the Question of Automatic Couplers (Subject VIII. for discussion at the seventh session of the Railway Congress). A. W. Gibbs. For America. Discussing the advantages and disadvantages, improvements, uses, &c. 10600 w. Bul Int Ry Cong—Jan., 1905. No. 67896 E.

On the Question of Automatic Couplers (Subject VII. for discussion at the seventh session of the Railway Congress). G. Noltein. Discusses the advantages and disadvantages, improvements in construction, use, &c. For all countries, except England and America. 11200 w. Table and fig. Bul Int Ry Cong—Jan., 1905. No. 67894 E.

Counterbalancing.

A Comparative Study of Locomotive Counterbalancing. Irving G. Downs. A study aiming to see approximately what effect the driving wheel still has upon the rail when counterbalanced by a gen-

We supply copies of these articles. See page 159.

erally accepted rule, and to make a comparison of the effects produced by the "Davis" type. Also discussion. 6800 w. Pro Cent Ry Club—Jan., 1905. No. 67814 C.

Locomotive Operation.

The Cost of Locomotive Operation. G. R. Henderson. A study aiming to give a clear understanding of the expenses with the effect of various influences. 2200 w. R R Gaz—Vol. XXXVIII, No. 7. Serial. 1st part. No. 67832.

Locomotives.

Advantages of Four-Cylinder Balanced Compound Locomotives. From "Record of Recent Construction," No. 49, issued by the Baldwin Locomotive Works, 1905. Discusses the advantages obtained and gives a record of test rules. Ills. 2000 w. R R Gaz—Vol. XXXVIII, No. 6. No. 67717.

A Michigan Central 2-8-0 Freighter. Illustrated description of a heavy consolidation freight engine. 600 w. Ry & Loc Engng—Feb., 1905. No. 67582 C.

A Recent Type of Italian Compound Express Locomotive. Dimensions, with illustrated detailed description of a locomotive of the "Italian crab engine" type. 450 w. Ry Age—Feb. 17, 1905. No. 67826.

Express Locomotives on the Bavarian State Railways. Illustration of one type of these engines, with description and dimensions. 1200 w. Engr, Lond—Jan. 27, 1905. No. 67693 A.

Freight Locomotive with Walschaert Valve Motion. An explanation of the Walschaert link motion, and an illustrated description of a Lake Shore locomotive, to which this valve gear has been applied. 700 w. Am Engr & R R Jour—Feb., 1905. No. 67603 C.

Narrow Gauge Tank Engine for Japan. Illustration, with brief description. 500 w. Ry & Loc Engng—Feb., 1905. No. 67580 C.

Prairie Type Locomotive for the Burlington. Brief illustrated description of new engines known as Class R-4. 500 w. Ry Age—Feb. 24, 1905. No. 68029.

Recent Locomotive Work on the Midland Railway. Charles Rous-Martin. The first of a series of articles reporting the performance by modern types of locomotives. 2200 w. Engr, Lond—Jan. 20, 1905. Serial. 1st part. No. 67541 A.

Six-Wheel Switcher, Southern Ry. Illustration and drawings, with description of switching engines for the Southern Railway. 500 w. Ry & Engng Rev—Feb. 18, 1905. No. 67863.

Tank Engines on Express Trains. Charles Rous-Martin. Discusses the suitability of these engines for fast running and some of the reasons pro and con. 4000 w. Engr, Lond—Feb. 10, 1905. No. 67879 A.

Tank Locomotives for Suburban Service on American Railways. A general summary concerning the use of tank locomotives for suburban service in the United States, giving brief illustrated descriptions of types used on various roads. 3000 w. Eng News—Feb. 16, 1905. No. 67807.

Train Lighting.

The Aichele Electric Train-Lighting System (Elektrische Zugbeleuchtung System Aichele). A single dynamo, driven from an axle, supplies current for the entire train, regulation being effected by a storage battery and automatic shunt. 2500 w. Elektrotech Zeitschr—Jan. 26, 1905. No. 67955 B.

On the Question of Lighting, Heating and Ventilation of Trains (Subject IX. for discussion at the Seventh Session of the Railway Congress). Charles B. Dudley. Considers improvements made in America. 1500 w. Table and fig. Bul Int Ry Cong—Jan., 1905. No. 67897 E.

Valve Gear.

Valve Gear for Four-Cylinder Compound Locomotives (Steuerung für Vier-Cylinder Verbudlokomotiven). Ernst Happel. Describing a modification of the Walschaert gear adapting it to both inside and outside cylinders. 800 w. Glasers Annalen—Jan. 15, 1905. No. 67928 D.

Wheels.

Proposed Specifications for Cast-Iron Wheels. C. W. Gennet, Jr. Gives specifications prepared with the purpose of defining the requirements of a satisfactory wheel and to provide for a method of testing. 1500 w. R R Gaz—Vol. XXXVIII, No. 6. No. 67719.

NEW PROJECTS.

New Construction.

San Pedro, Los Angeles, & Salt Lake Railroad. An illustrated account describing the new line from Salt Lake to the Pacific, including new and reconstructed lines. 3000 w. Ry Age—Feb. 10, 1905. No. 67737.

PERMANENT WAY AND BUILDINGS.

Construction.

General Engineering Features of the Denver, Northwestern & Pacific Ry. Brief illustrated description of the construction of this line between Denver, Colo., and Salt Lake, Utah. 1600 w. Eng Rec—Feb. 25, 1905. No. 68044.

Facing-Point.

High-Speed Facing-Points. An illus-

trated description of a new form of facing-point, called the St. George-Moore high-speed facing point, with explanation of the principle and the objects aimed to accomplish. 1400 w. Engng—Jan. 27, 1905. No. 67690 A.

Location.

Methods of Location on the Choctaw, Oklahoma and Gulf Railroad. Discussion of paper by F. Lavis. 3500 w. Pro Am Soc of Civ Engrs—Feb., 1905. No. 68048 E.

Power Plant.

The Chicago and Western Indiana Power House. Illustrated description of a plant for furnishing steam heat, compressed air and water supply to the coach yards and adjacent buildings, and for generating electricity for lighting passenger stations, freight houses, yard, subways, &c. 2000 w. Ry Age—Feb. 24, 1905. No. 68028.

Roundhouses.

New Roundhouses at Elkhart. Illustrated description of the arrangement of shops, power house and other buildings, and an account of the rapid inspection and repairs accomplished with the facilities at this Indiana plant of the Lake Shore & Michigan Southern Railway. 1600 w. Am Engr & R R Jour—Feb., 1905. No. 67602 C.

Shops.

New Shops of the Pere Marquette R. R. at Grand Rapids, Mich. Illustrated detailed description. 2000 w. Ry Mas Mech—Feb., 1905. Serial. 1st part. No. 67633.

Signals.

Block Signals on American Railroads. A discussion of signal arrangements in America from the English point of view. 1600 w. Engr, Lond—Jan. 27, 1905. No. 67694 A.

Block Signaling on Lines of Light Traffic. Describes examples on the Chesapeake & Ohio, and the manner of working, with comments on the conditions and cost. 2000 w. R R Gaz—Vol. XXXVIII, No. 6. No. 67718.

Modern Railway Signal Practice. Ernest C. Webster. A review of the development of fixed signals, with illustrations. 5000 w. Yale Sci M—Feb., 1905. No. 67892 C.

New System of All-Electric Interlocking. Illustrates and describes an installation at Millbury Junction, Ohio. 3800 w. Ry & Engng Rev—Feb. 18, 1905. No. 67862.

Signals and Signaling. George Sherwood Hodgins. An illustrated article describing the electric train staff system as used on four or five roads in the United States. 1800 w. Ry & Loc Engng—Feb., 1905. No. 67579 C.

Terminals.

Chicago Freight Transfers and Deliveries. A discussion of the subject as it appears in Chicago, explaining the plan suggested by Frederic A. Delano, describing present arrangements, the Illinois Tunnel Co.'s conduits, &c. Ills. 4800 w. Ry Age—Feb. 3, 1905. No. 67622.

Ties.

On the Question of Wooden Sleepers or Crossties. Selection of Species of Timber Used and Processes of Preservation (Subject I-A, for discussion at the seventh session of the Railway Congress). J. W. Kendrick. On the selection of the kinds of wood and the processes of preservation of railway ties. For America. 18000 w. Tables and fig. Bul Int Ry Cong—Jan., 1905. No. 67893 E.

Yards.

Chicago & Western Indiana's New Passenger Car Yard, Chicago. Illustrated detailed description of the construction and equipment of a new yard for cleaning and repairing coaches. 3300 w. Ry Age—Feb. 17, 1905. No. 67828.

STREET AND ELECTRIC RAILWAYS

Boston Tunnel.

The Equipment of the East Boston Tunnel. Considers features of interest in the roadbed, track, lighting, power supply, and ventilation systems, outlining the main physical characteristics of the tunnel. 3500 w. St Ry Jour—Jan. 28, 1905. No. 67553 C.

Braking.

A New Hydro-Electric Braking System. Illustrated detailed description of system designed by Charles A. Mudge. 1500 w. St Ry Jour—Jan. 28, 1905. No. 67556 C.

Car Storage.

Car Storage Houses vs. Operating Barns. D. F. Carver. Discusses the plans for storing out-of-service cars, and gives an illustrated description of the car-house for storage purposes built in Newark, N. J. 1800 w. St Ry Jour—Feb. 4, 1905. No. 67646 C.

We supply copies of these articles. See page 159.

Detroit Shops.

Shop Equipment of the New Repair Shops Installation of the Detroit United Railway Company. An illustrated account of some of the more important features of the mechanical equipment and operative methods. 3500 w. St Ry Jour—Feb. 18, 1905. No. 67861 C.

Electric Locomotives.

A New Shifting Locomotive for the Brooklyn Rapid Transit Company. Illustrates and describes an interesting electric locomotive especially designed for the shifting of cars. 1500 w. St Ry Jour—Feb. 25, 1905. No. 68031 C.

New Locomotives on the Valtellina Railway. Gives illustrations and interesting particulars of these locomotives, taken from an article by Béla Valatin, in *Elektrische Bahnen u. Betriebe*. 2000 w. Elec Engr, Lond—Feb. 3, 1905. Serial. 1st part. No. 67779 A.

Electric Traction.

Developments in Electric Traction. W. B. Potter. Compares alternating and direct current systems, gives statistics of steam and electric operation, describes recent equipment, and other features of interest pertaining to electric traction. General discussion. Ills. 19400 w. Pro N Y R R Club—Jan. 20, 1905. No. 67794.

Electrification.

Metropolitan District Railway Electrification. An illustrated comprehensive account of the electrical equipment of this underground road and of the great power-station at Chelsea. 34000 w. Tram & Ry Wld—Feb. 9, 1905. No. 67877 B.

The Electrification of the District Railway. Begins an illustrated detailed description of this work. 1500 w. Engr, Lond—Feb. 3, 1905. Serial. 1st part. No. 67791 A.

Fayet-Chamonix.

The Fayet-Chamonix Electric Railway. Dr. Alfred Gradenwitz. Illustrated detailed description of this line and its construction. 2000 w. Elec Engr, Lond—Jan. 27, 1905. No. 67677 A.

Fire Inspections.

Fire Inspections and Fire Precautions in Hartford, Conn. An illustrated account of the system of inspection in conjunction with methods of construction in all the buildings belonging to the Street Railway Company. 2000 w. St Ry Jour—Feb. 4, 1905. No. 67645 C.

Generating Stations.

See Electrical Engineering.

Interurban.

Completion of the Interurban Link Between Toledo and Detroit. Illustrated description of the new construction from Monroe to Detroit. The total length of the system as now operated is 56 miles, the extension embracing 35 miles of the distance. 4500 w. St Ry Jour—Jan. 28, 1905. No. 67552 C.

New York and Stamford Railway Co. Putnam A. Bates. Brief illustrated account of the railways consolidated to form this line. 2000 w. St Ry Rev—Feb. 15, 1905. No. 68015 C.

The Cœur d'Alene & Spokane Railway. Describes the situation and conditions in this region, giving an illustrated description of the railway and its equipment and operation. It handles freight as well as passengers. 1800 w. St Ry Jour—Feb. 11, 1905. No. 67741 C.

The Iowa & Illinois Railway Co. Illustrates and describes the line, power plant, rolling stock and operating methods of a recently completed interurban line between Clinton and Davenport, Iowa. 5500 w. St Ry Rev—Feb. 15, 1905. No. 68013 C.

The New Interurban Line of the Lansing & Suburban Traction Company. I. L. Dixon. An illustrated article briefly outlining the history of this undertaking and describing the line as now operated. 4500 w. St Ry Jour—Feb. 25, 1905. No. 68030 C.

The Street and Interurban Railway System at Terre Haute, Indiana. States the conditions which have led to the rapid increase in population in this district, and gives an illustrated description of the street and interurban railway development. 6500 w. St Ry Jour—Feb. 4, 1905. No. 67643 C.

Metropolitan Ry.

Sub-Stations and Automatic Signalling on the District Railway. Describes the Charing Cross sub-station as a type, and the system of signalling installed. Ills. 4700 w. Elect'n, Lond—Feb. 3, 1905. No. 67782 A.

N. Y. Subway.

New York Subway. Roger A. Selby. An illustrated article describing this great engineering work, and briefly reviewing its history. 3000 w. Yale Sci M—Jan., 1905. No. 67774 C.

Operation.

Electric Railway Operation in a Great City. H. H. Vreeland. Abstract of an address before the N. Y. Elec. Soc. Calls attention to points bearing on the electrical engineer in this branch of the industry. 4800 w. St Ry Jour—Feb. 25, 1905. No. 68033 C.

We supply copies of these articles. See page 159.

Paris.

Paris Metropolitan Railway Co. M. Vingoe. Illustrated description of line No. 3, extending from Courcelles to Père Lachaise, five miles, recently opened. 2000 w. St Ry Rev—Feb., 1905. No. 68014 C.

The New Paris Electric Railroad. C. L. Durand. Illustrates and describes the equipment of the Paris-Orleans electric railroad. 3200 w. Elec Rev, N. Y.—Feb. 18, 1905. No. 67830.

Philadelphia Subway.

The Subway of the Philadelphia Rapid Transit Co. Illustrated detailed description. 4500 w. Eng Rec—Feb. 25, 1905. No. 68045.

Power.

Steam Power. E. R. Roberts. Read before the Ohio Interurban Ry. Assn. Discusses the power needed for interurban electric railways, the operating conditions, and the importance of making comparisons on the basis of operating conditions. 5000 w. St Ry Jour—Feb. 11, 1905. No. 67743 C.

Power-Distribution.

The Power Distribution System of the Louisville Railway Company. Illustrated description of an extensive polyphase power-distribution system recently installed. 1400 w. St Ry Jour—Feb. 11, 1905. No. 67742 C.

Prime Movers.

Steam Power for Electric Railways. E. P. Roberts. Read before the Ohio Interurban Ry. Assn. Discusses the factors to be considered in deciding upon a prime mover, giving a special study of steam power, the effects of grades, cost, &c. 4500 w. Eng Rec—Feb. 18, 1905. No. 67849.

Repair Shops.

The New Repair Shop Plant of the Detroit United Railway. An illustrated account of the new repair shop installation and the methods pursued there. 3800 w. St Ry Jour—Feb. 11, 1905. No. 67740 C.

Service.

Limited Service and Interline Business. A review of the conveniences and possibilities for fast long distance travel on electric railways. 4500 w. St Ry Jour—Feb. 4, 1905. No. 67644 C.

Shop Methods.

Shop Methods at the Repair Shops of the Detroit United Railway Company. A supplementary article to two preceding, relative to this new repair shop. Describes method of handling cars, truck shop, erecting shop, storage air brakes, &c. Ills. 6000 w. St Ry Jour—Feb. 25, 1905. No. 68032 C.

Single-Phase.

Opening of the Indianapolis & Cincinnati Single Phase Line. Illustrated detailed description of the road and its equipment. 4000 w. St Ry Jour—Feb. 18, 1905. No. 67859 C.

The Indianapolis & Cincinnati Traction Company. Illustrates and describes a practical application of the single-phase system to an interurban railway. 4500 w. Elec Rev, N. Y.—Feb. 18, 1905. No. 67831.

Snow Removal.

Snow Removal in Syracuse. E. G. Connette. Brief illustrated account of methods found successful in a city subject to heavy snow fall. 600 w. St Ry Jour—Jan. 28, 1905. No. 67554 C.

South Africa.

Electrical Installations of the Natal Government Railways, South Africa. An illustrated description of the new power station at Durban, and its equipment. 2500 w. Elec Rev, Lond—Feb. 10, 1905. No. 67872 A.

Tokio.

The Tokio Tramway Company. E. A. Baldwin. Brief illustrated description. 1000 w. St Ry Jour—Feb. 18, 1905. No. 67860 C.

Tracks.

New Track Systems for City Streets. Gives views recently expressed by street railway officers, with illustrations of various types of construction. 1700 w. Eng Rec—Feb. 25, 1905. No. 68043.

Recent Methods of Construction and Pavement of Tracks in Boston. Arthur L. Plimpton. Illustrated detailed description. 700 w. St Ry Jour—Feb. 4, 1905. No. 67647 C.

Valtellina.

Experiences and Results with Polyphase Current on the Valtellina Railway (Erfahrungen und Ergebnisse mit Hochgespanntem Drehstrom auf der Valtellina Bahn). Eugen Cserhati. Results of the past two years' operation, showing the success of the line from a technical and commercial standpoint. 3500 w. Zeitschr d Ver Deutscher Ing—Jan. 28, 1905. No. 67907 D.

Wheels.

Wear of Steel Tired Wheels—How to Eliminate Excessive Flange Wear. W. G. Price. Considers the cause of excessive wear to be due to faulty truck construction. 1000 w. St Ry Rev—Feb. 15, 1905. No. 68016 C.

We supply copies of these articles. See page 159.

EXPLANATORY NOTE—THE ENGINEERING INDEX.

We hold ourselves ready to supply—usually by return of post—the full text of every article indexed in the preceding pages, *in the original language*, together with all accompanying illustrations; and our charge in each case is regulated by the cost of a single copy of the journal in which the article is published. The price of each article is indicated by the letter following the number. When no letter appears, the price of the article is 20 cts. The letter A, B or C denotes a price of 40 cts.; D, of 60 cts.; E, of 80 cts.; F, of $1.00; G, of $1.20; H, of $1.60. Certain journals, however, make large extra charges for back numbers. In such cases we may have to increase proportionately the normal charge given in the Index. In ordering, care should be taken to *give the number* of the article desired, not the title alone.

Serial publications are indexed on the appearance of the first installment.

SPECIAL NOTICE.—To avoid the inconvenience of letter-writing and small remittances, especially from foreign countries, and to cheapen the cost of articles to those who order frequently, we sell coupons at the following prices:—20 cts. each or twelve for $2.00, thirty-three for $5, and one hundred for $15.

Each coupon will be received by us in payment for any 20-cent article catalogued in the Index. For articles of a higher price, one of these coupons will be received for each 20 cents; thus, a 40-cent article will require two coupons; a 60-cent article, three coupons; and so on. The use of these coupons is strongly commended to our readers. They not only reduce the cost of articles 25 per cent. (from 20c. to 15c.), but they need only a trial to demonstrate their very great convenience—especially to engineers in foreign countries, or away from libraries and technical club facilities.

Write for a sample coupon—free to any part of the world.

CARD INDEX.—These pages are issued separately from the Magazine, printed on one side of the paper only, and in this form they meet the exact requirements of those who desire to clip the items for card-index purposes. Thus printed they are supplied to regular subscribers of THE ENGINEERING MAGAZINE at 10 cts. per month, or $1.00 a year; to non-subscribers, 25 cts. per month, or $3.00 a year.

THE PUBLICATIONS REGULARLY REVIEWED AND INDEXED.

The titles and addresses of the journals regularly reviewed are given here in full, but only abbreviated titles are used in the Index. In the list below, *w* indicates a weekly publication, *b-w*, a bi-weekly, *s-w*, a semi-weekly, *m*, a monthly, *b-m*, a bi-monthly, *t-m*, a tri-monthly, *qr*, a quarterly, *s-q*, semi-quarterly, etc. Other abbreviations used in the index are: Ill—Illustrated; W—Words; Anon—Anonymous.

Alliance Industrielle. *m.* Brussels.
American Architect. *w.* Boston.
American Electrician. *m.* New York.
Am. Engineer and R. R. Journal. *m.* New York.
American Jl. of Science. *m.* New Haven, U.S.A.
American Machinist. *w.* New York.
Annales des Ponts et Chaussées. *m.* Paris.
Ann. d Soc. d Ing. e d Arch. Ital. *w.* Rome.
Architect. *w.* London.
Architectural Record. *qr.* New York.
Architectural Review. *s-q.* Boston.
Architect's and Builder's Magazine. *m.* New York.
Australian Mining Standard. *w.* Melbourne.
Autocar. *w.* Coventry, England.
Automobile. *m.* New York.
Automobile Magazine. *m.* New York.
Automotor Journal. *w.* London.
Beton und Eisen. *qr.* Vienna.
Brit. Columbia Mining Rec. *m.* Victoria, B. C.
Builder. *w.* London.
Bulletin American Iron and Steel Asso. *w.* Philadelphia, U. S. A.
Bulletin de la Société d'Encouragement. *m.* Paris.
Bulletin of Dept. of Labor. *b-m.* Washington.
Bull. Soc. Int. d Electriciens. *m.* Paris.
Bulletin of the Univ. of Wis., Madison, U. S. A.
Bulletin Univ. of Kansas. *b-m.* Lawrence.
Bull. Int. Railway Congress. *m.* Brussels.
California Jour. of Tech. *m.* Berkeley, Cal.
Canadian Architect. *m.* Toronto.
Canadian Electrical News. *m.* Toronto.
Canadian Engineer. *m.* Toronto and Montreal.
Canadian Mining Review. *m.* Montreal.
Cassier's Magazine. *m.* New York and London.
Cement. *b.-m.* New York.
Cement Age. *m.* New York.
Central Station. *m.* New York.
Chem. Met. Soc. of S. Africa. *m.* Johannesburg.

Colliery Guardian. *w.* London.
Compressed Air. *m.* New York.
Comptes Rendus de l'Acad. des Sciences. *w.* Paris.
Consular Reports. *m.* Washington.
Deutsche Bauzeitung. *b-w.* Berlin.
Domestic Engineering. *m.* Chicago.
Electrical Engineer. *w.* London.
Electrical Review. *m.* London.
Electrical Review. *w.* New York.
Electrical World and Engineer. *w.* New York.
Electric Club Journal. *m.* Pittsburg, Pa.
Electrician. *w.* London.
Electricien. *w.* Paris.
Electricity. *w.* London.
Electrochemical and Met. Industry. *m.* New York.
Electrochemist and Metallurgist. *w.* London.
Elektrochemische Zeitschrift. *m.* Berlin.
Elektrotechnische Zeitschrift. *w.* Berlin.
Elettricita. *w.* Milan.
Engineer. *w.* London.
Engineer. *s-m.* Chicago.
Engineering. *w.* London.
Engineering and Mining Journal. *w.* New York.
Engineering Magazine. *m.* New York & London.
Engineering News. *w.* New York.
Engineering Record. *w.* New York.
Engineering Review. *m.* London.
Eng. Soc. of Western Penna. *m.* Pittsburg, U.S.A.
Engineering Times. *m.* London.
Fire and Water. *w.* New York.
Foundry. *m.* Cleveland, U. S. A.
Génie Civil. *w.* Paris.
Gesundheits-Ingenieur. *s-m.* München.
Giorn. Dei Lav. Pubb. e. d. Str. Ferr. *w.* Rome.
Glaser's Ann. f Gewerbe & Bauwesen. *s-m.* Berlin.
Ice and Refrigeration. *m.* New York.
Ill. Zeitschr. f. Klein u. Strassenbahnen. *s-m.* Berlin.
Industry. *m.* New York.
Ingenieria. *b-m.* Buenos Ayres.
Ingenieur. *w.* Hague.
Insurance Engineering. *m.* New York.
Iron Age. *w.* New York.
Iron and Coal Trades Review. *w.* London.
Iron and Steel Metallurgist. *m.* Boston.
Iron and Steel Trades Journal. *w.* London.
Iron Trade Review. *w.* Cleveland, U. S. A.
Jour. Am. Foundrymen's Assoc. *m.* New York.
Journal Asso. Eng. Societies. *m.* Philadelphia.
Journal of Electricity. *m.* San Francisco.
Journal Franklin Institute. *m.* Philadelphia.
Journal of Gas Lighting. *w.* London.
Journal Royal Inst. of Brit. Arch. *s-qr.* London.
Jour. Roy. United Service Inst. *m.* London.
Journal of Sanitary Institute. *qr.* London.
Jour. of South African Assn. of Engineers. *m.* Johannesburg, S. A.
Journal of the Society of Arts. *w.* London.
Journal of U. S. Artillery *b-m.* Fort Monroe, U.S.A.
Journal Western Soc. of Eng. *b-m.* Chicago.
Journal of Worcester Poly. Inst., Worcester, U.S.A.
Locomotive. *m.* Hartford, U. S. A.
Machinery. *m.* New York.
Madrid Cientifico. *t-m.* Madrid.
Marine Engineering. *m.* New York.
Marine Review. *w.* Cleveland, U. S. A.
Mem. de la Soc. des Ing. Civils de France. *m.* Paris.
Métallurgie. *w.* Paris.
Minero Mexicano. *w.* City of Mexico.
Mines and Minerals. *m.* Scranton, U. S. A.
Mining and Sci Press. *w.* San Francisco.
Mining Journal. *w.* London.
Mining Magazine. *m.* New York.
Mining Reporter. *w.* Denver, U. S. A.
Mittheilungen des Vereines für die Förderung des Local und Strassenbahnwesens. *m.* Vienna.
Municipal Engineering. *m.* Indianapolis, U. S. A.
Municipal Journal and Engineer. *m.* New York.
Nature. *w.* London.
Nautical Gazette. *w.* New York.
New Zealand Mines Record. *m.* Wellington.
Nineteenth Century. *m.* London.
Oest. Wochenschr. f. d. Oeff. Baudienst. *w.* Vienna.
Oest. Zeitschr. Berg- & Hüttenwesen. *w.* Vienna.
Page's Weekly. *w.* London.
Plumber and Decorator. *m.* London.
Popular Science Monthly. *m.* New York.
Power. *m.* New York.
Practical Engineer. *w.* London.
Pro. Am. Soc. Civil Engineers. *m.* New York.
Pro. Canadian Soc. Civ. Engrs. *m.* Montreal.
Proceedings Engineers' Club. *qr.* Philadelphia.
Pro. St. Louis R'way Club. *m.* St. Louis, U. S. A.
Public Works. *qr.* London.
Quarry. *m.* London.
Queensland Gov. Mining Jour. *m.* Brisbane, Australia.
Railroad Gazette. *w.* New York.
Railway Age. *w.* Chicago.
Railway & Engineering Review. *w.* Chicago
Railway and Loc. Engng. *m.* New York.
Review of Reviews. *m.* London & New York.
Revista d Obras. Pub. *w.* Madrid.
Revista Tech. Ind. *m.* Barcelona.
Revue de Mécanique. *m.* Paris.
Revue Gen. des Chemins de Fer. *m.* Paris.
Revue Gen. des Sciences. *w.* Paris.
Revue Industrielle. *w.* Paris.
Revue Technique. *b-m.* Paris.
Revue Universelle des Mines. *m.* Liége.
Rivista Gen. d Ferrovie. *w.* Florence.
Rivista Marittima. *m.* Rome.
Schiffbau. *s-m.* Berlin.
Schweizerische Bauzeitung. *w.* Zürich.
Scientific American. *w.* New York.
Scientific Am. Supplement. *w.* New York.
Sibley Jour. of Mech. Engng. *m.* Ithaca, N. Y.
Stahl und Eisen. *s-m.* Düsseldorf.
Stevens' Institute Indicator. *qr.* Hoboken, U.S.A.
Street Railway Journal. *m.* New York.
Street Railway Review. *m.* Chicago.
Tijds. v h Kljk. Inst. v Ing. *qr.* Hague.
Traction and Transmission. *m.* London.
Tramway & Railway World. *m.* London.
Trans. Am. Ins. Electrical Eng. *m.* New York.
Trans. Am. Ins. of Mining Eng. New York.
Trans. Am. Soc. Mech. Engineers. New York.
Trans. Inst. of Engrs. & Shipbuilders in Scotland, Glasgow.
Transport. *w.* London.
World's Work. *m.* New York.
Yacht. *w.* Paris.
Zeitschr. d. Mitteleurop. Motorwagen Ver. *s-w.* Berlin.
Zeitschr. d. Oest. Ing. u. Arch. Ver. *w.* Vienna.
Zeitschr. d. Ver. Deutscher Ing. *w.* Berlin.
Zeitschrift für Elektrochcemie. *w.* Halle a S.
Zeitschr. f. Elektrotechnik. *w.* Vienna.